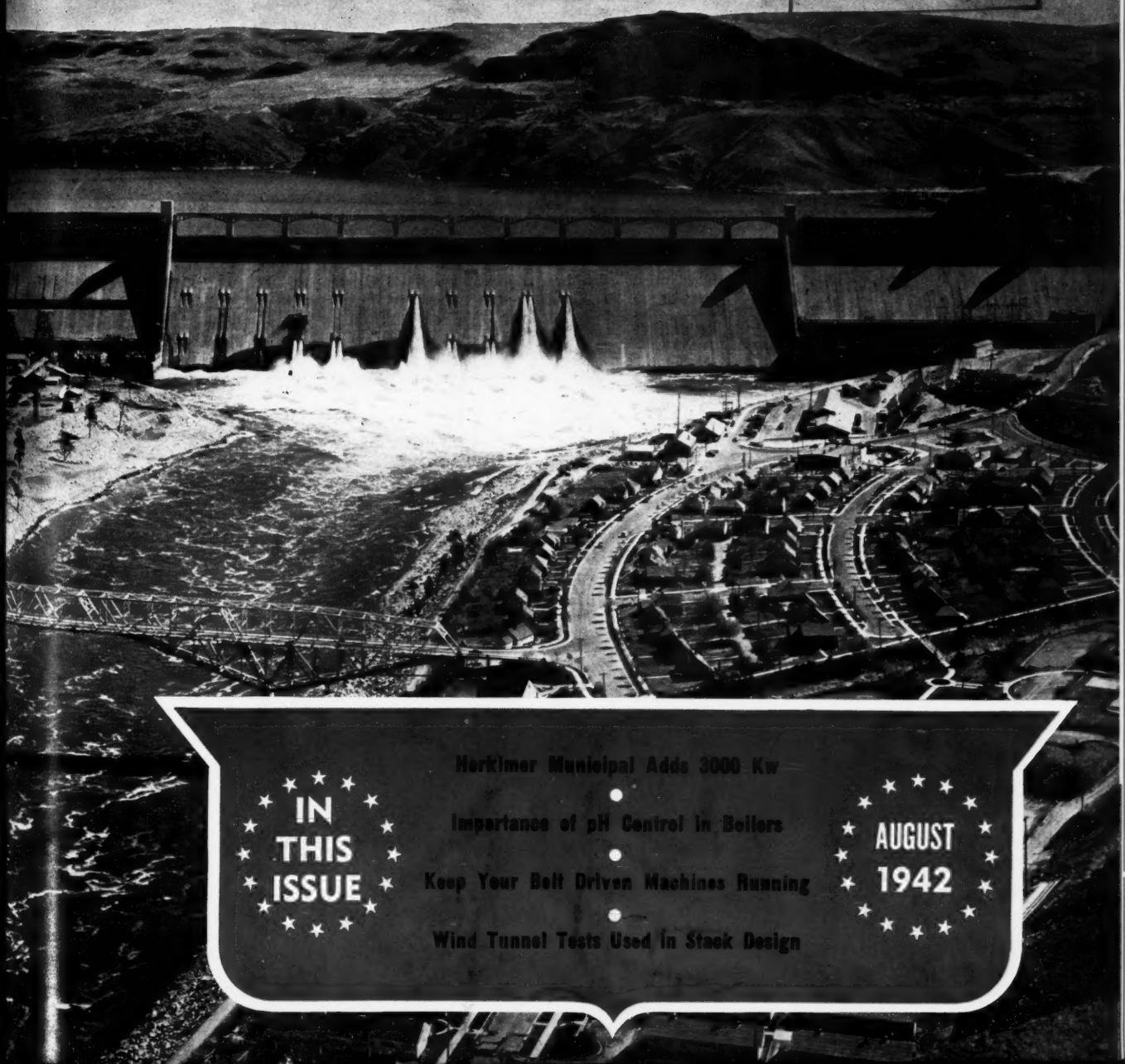
POWER PLANT ENGINEERING

THE PLANT ENGINEERING AND MAINTENANCE MAGAZINE FOR EVERY INDUSTRY

PUBLIC LIBRARY
AUG 5 - 1942
DETROIT

Grand Coulee Dam, giant arsenal of hydro-power for vital war industries of the Northwest



IN THIS ISSUE

Herkimer Municipal Adds 3000 Kw

Importance of pH Control in Boilers

Keep Your Belt Driven Machines Running

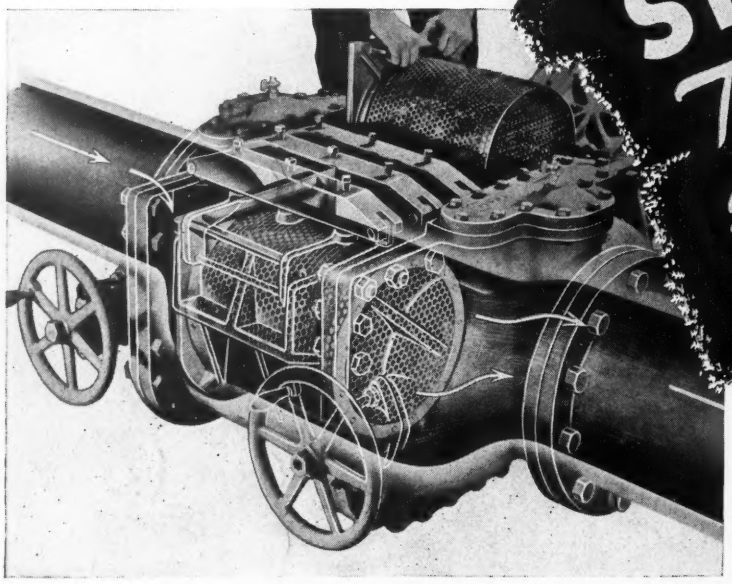
Wind Tunnel Tests Used in Stack Design

AUGUST 1942

They trap trouble

ELLIOTT STRAINERS

The power plant's service of security



TWIN STRAINERS — standard equipment for clearing water and other liquids. One side always in operation while the other is shut off for cleaning. Sizes 2 in. to 42 in. Working pressures up to 150 lb. Single strainers, too, where occasional shut-down is allowable.

TWIN OIL STRAINERS (at right) built on same principle as above, especially for use with fuel and lubricating oil, and process liquids. Sizes 1 in. to 12 in., pressures to 300 lb.

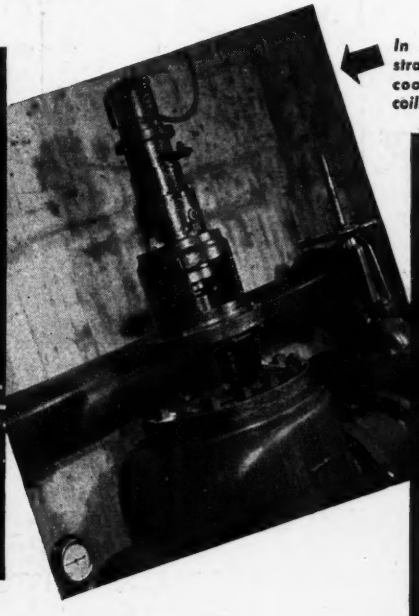
ELLIOTT

to hasten VICTORY

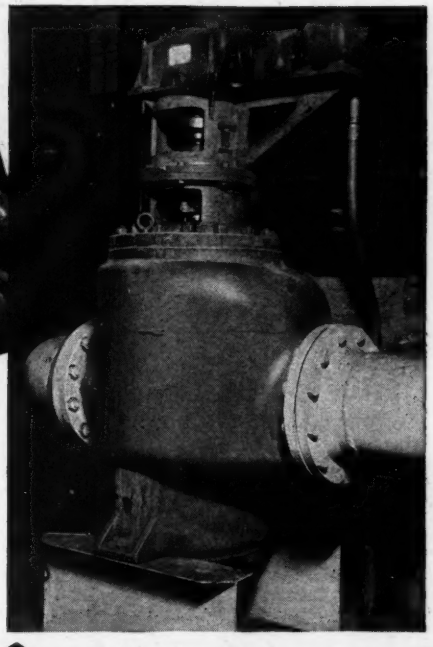
They avert calamities, these Elliott strainers. With unsleeping vigilance they render harmless the bits of debris, trash and foreign matter in water or oil that would otherwise score valve seats, jam or break pistons, clog lubricating lines, cause burners to fail, and all in all create enough delay, breakage and trouble to make glad the heart of any fifth columnist.

Thousands of Elliott strainers in various types are serving the nation on shipboard, keeping oil and water lines clear . . . in power plants large and small . . . in the process industries, straining liquids and solutions of various kinds, such as paint, molasses, tar. Their uses are manifold — their combined protective value enormous. It is safe to say that should all the Elliott strainers now in service suddenly cease operation, the result would be as bad as a fair-sized naval defeat.

If you have a straining question to answer, use the expert help of Elliott engineers.



In a hydro plant — one of five straining water for transformer cooling and generator cooling coils, and fire apparatus.



In a central station—one of three self-cleaning strainers which provide clear water for bearing cooling.

CONTINUOUS STRAINERS

clean themselves, need no attention. Used on water lines, continuous backflow automatically flushing out foreign matter. Especially valuable where large quantities of fine dirt, etc., must be removed. Sizes, 4 in. to 24 in., pressure to 125 lb.

A-272

COMPANY

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JEANNETTE, PA.
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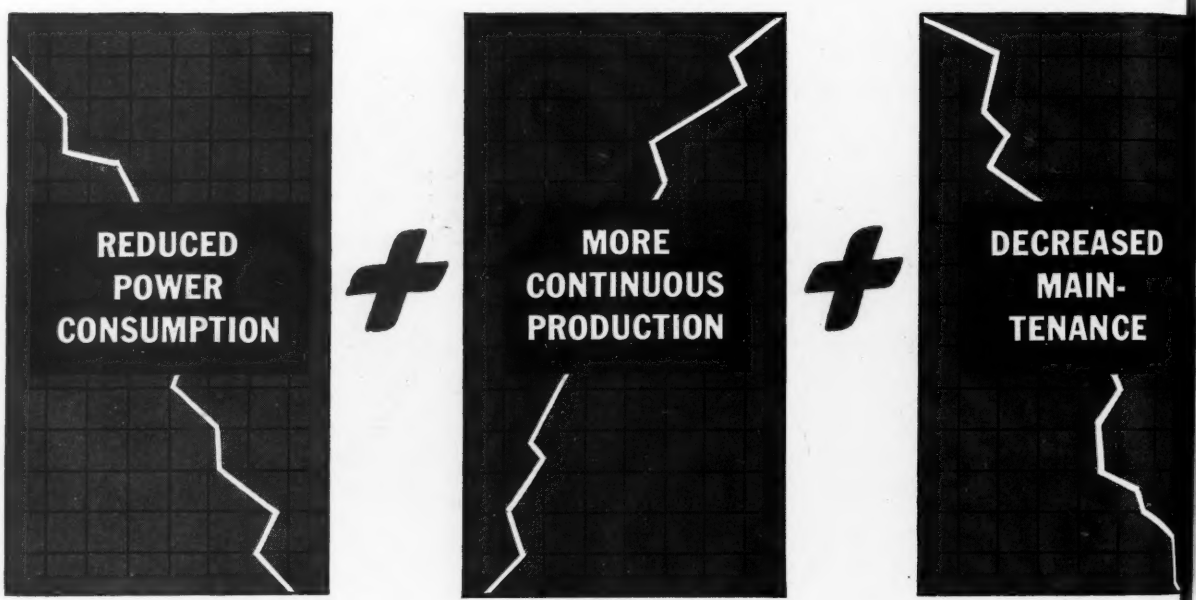
STRAINERS • SEPARATORS • GREASE EXTRACTORS • NON-RETURN VALVES • LAGONDA-LIBERTY TUBE CLEANERS

SOCONY-VACUUM'S FAMOUS LUBRICATION

Capacity



The "4-Factor" Story proved in Peacetime—Now vital in Wartime

GARGOYLE Lubricants

NEVER BEFORE IN U. S. A. HISTORY has there been such grim, absolute necessity for Correct Lubrication. It's a keystone in our Battle of Production. Without it no plant can achieve full efficiency.

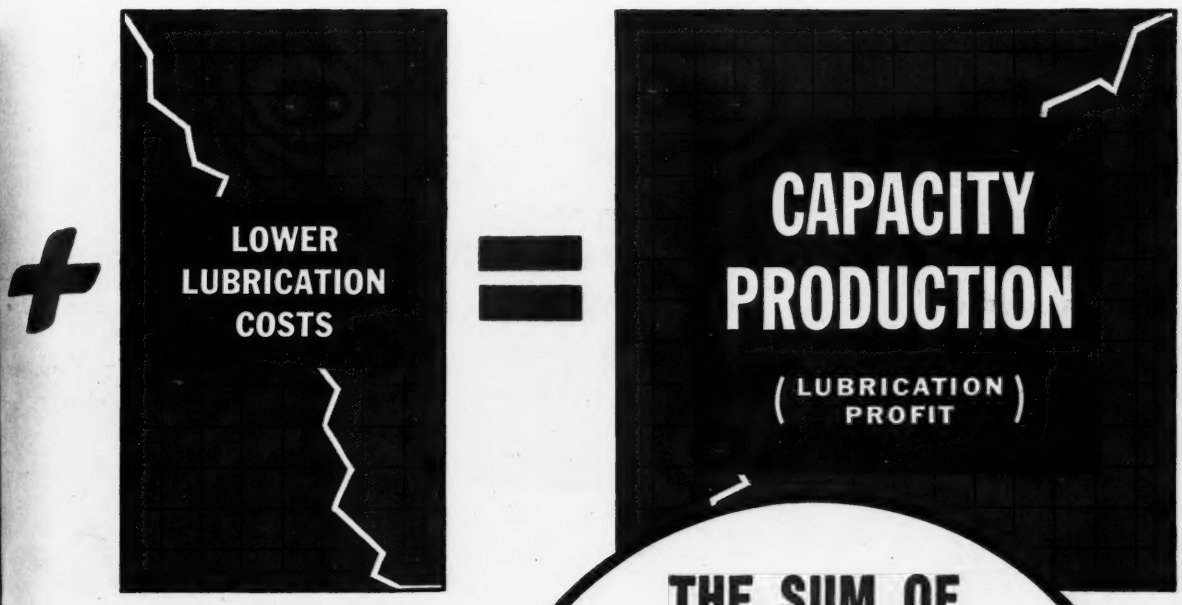
For years Socony-Vacuum—*the first to present and apply the principle of Correct Lubrication*—has been proving to management that it results in 4 savings which add up to a Lubrication Profit. Today, this Lubrication Profit pays off in Capacity Production!

If you are interested in results, talk this over with the Socony-Vacuum man. Backed by 76 years' experience, no one in the lubrication field is better equipped than he to give you the results you want!

CALL IN SOCONY-VACUUM FOR CORRECT

PROFIT NOW PAYS OFF IN...

Production!



Socony-Vacuum's 4-FACTOR STORY is a Famous guide for operating men throughout U.S.A. Industry

THE SUM OF THESE FOUR SAVINGS

4

1. REDUCED POWER CONSUMPTION
2. MORE CONTINUOUS PRODUCTION
3. DECREASED MAINTENANCE
4. LOWER LUBRICATION COSTS

=LUBRICATION PROFIT

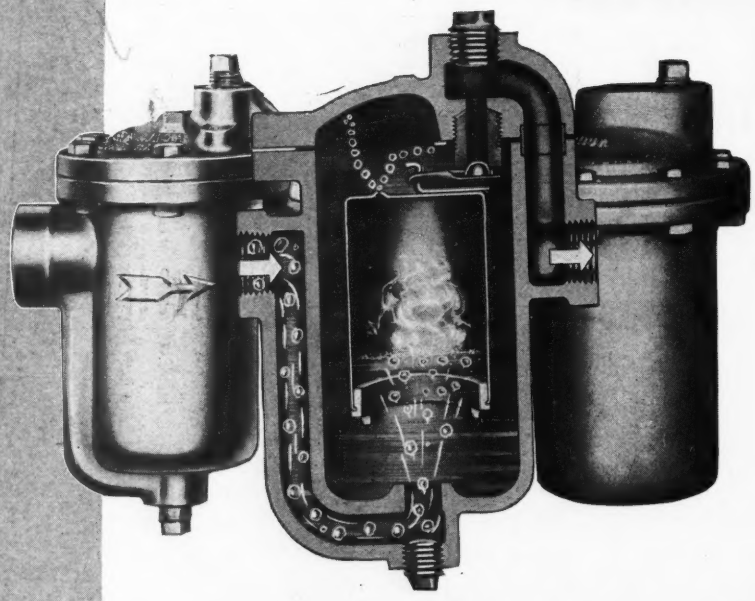
SOCONY-VACUUM OIL CO., INC. • Standard Oil of N. Y. Div. • White Star Div. • Lubrite Div. • Chicago Div. • White Eagle Div. • Wadhams Div. • Southeastern Div. (Baltimore) Magnolia Petroleum Co. • General Petroleum Corp. of Calif.

LUBRICATION

Published monthly by the Technical Publishing Co., at 53 West Jackson Blvd., Chicago, Ill., U. S. A. Subscription price, $2.00 a year. Single copies current issue, 25c. Entered as second class matter September 8, 1932, at the Post Office, Chicago, Ill. under act of March 3, 1879. Vol. XLVI, No. 8.

ARMSTRONG

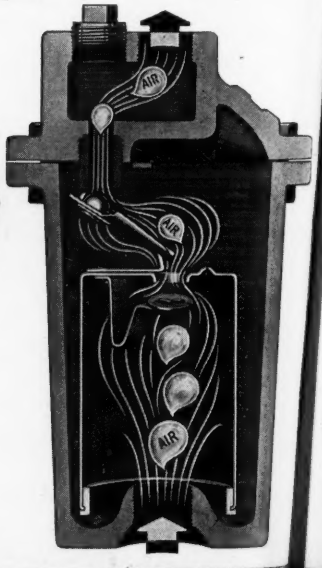
For "ALL-OUT"



★ **BIG CAPACITY.** Armstrong's distinctive "free-floating" valve mechanism permits use of considerable larger discharge orifices than possible with ordinary lever arrangements.

★ **NO STEAM LOSS.** The Armstrong Trap is suitable for variable load conditions and no steam passes through the discharge orifice even when there is no condensate load.

★ **AUTOMATIC AIR ELIMINATION.** Any air entering the trap ahead of condensate or coming in with the steam passes through the small vent in the top of the inverted bucket. This air collects at the top of the trap and is discharged ahead of the condensate when the valve opens.



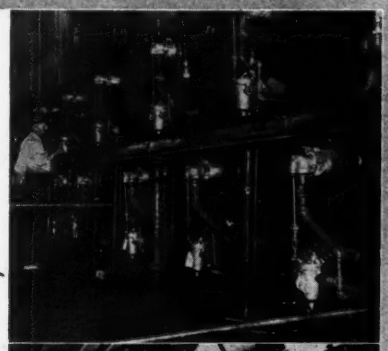
Use this special thermic vent bucket for EXTRA FAST air removal!

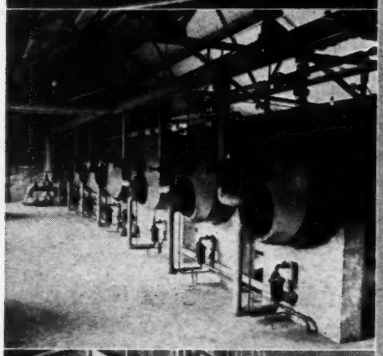
SEE OUR CATALOG IN SWEET'S

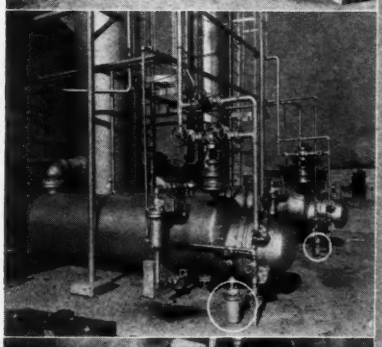
WHERE large amounts of air must be handled quickly when steam is first turned on the use of an Armstrong Blast Trap will often work wonders in speeding up heating. An Armstrong Blast Trap differs from a standard trap only in that the inverted bucket is equipped with an auxiliary air vent which is controlled by a flat disc mounted at the end of a strip or rustless thermostatic bi-metal. Air and water blow straight through (see picture at right) until steam comes in and causes the bi-metal strip to bend upward, closing the auxiliary vent.

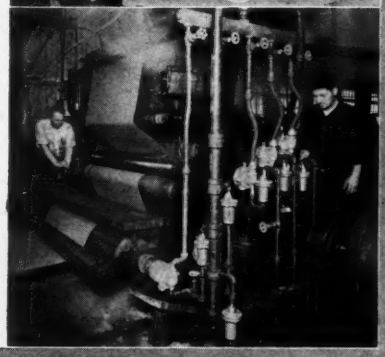
ARMSTRONG *Inverted Bucket*

SPEED
in the Battle of Production!









ALL-OUT speed in the Battle of Production means that production equipment in countless plants must deliver maximum output without interruption. Throughout the land, where steam is used, Armstrong Traps have taken their place in the battle line.

SHORTAGE of fuel and rationing of power—the two menaces encouraged by inefficient utilization of steam—get no encouragement from Armstrong Steam Traps. Numerous users have reported that the steam saved by putting in Armstrong traps gave them the power equivalent to an extra boiler without the actual cost of putting in a boiler and firing it.

MILITARY STRENGTH and Industrial Efficiency go Hand in Hand! Time and man-power used up in wasted power, wasted steam, wasted fuel means just that much less potentially available for the main effort. Armstrong traps also protect users against excessive maintenance and loss of output.

ARMSTRONG offers a wealth of helpful, timesaving information to help users of steam secure peak performance. We will be glad to supply you with a copy of the newest edition of the popular 36 page Armstrong Steam Trap Book for solving virtually any condensate drainage problem encountered in an industrial plant. See your local Armstrong Representative or write.

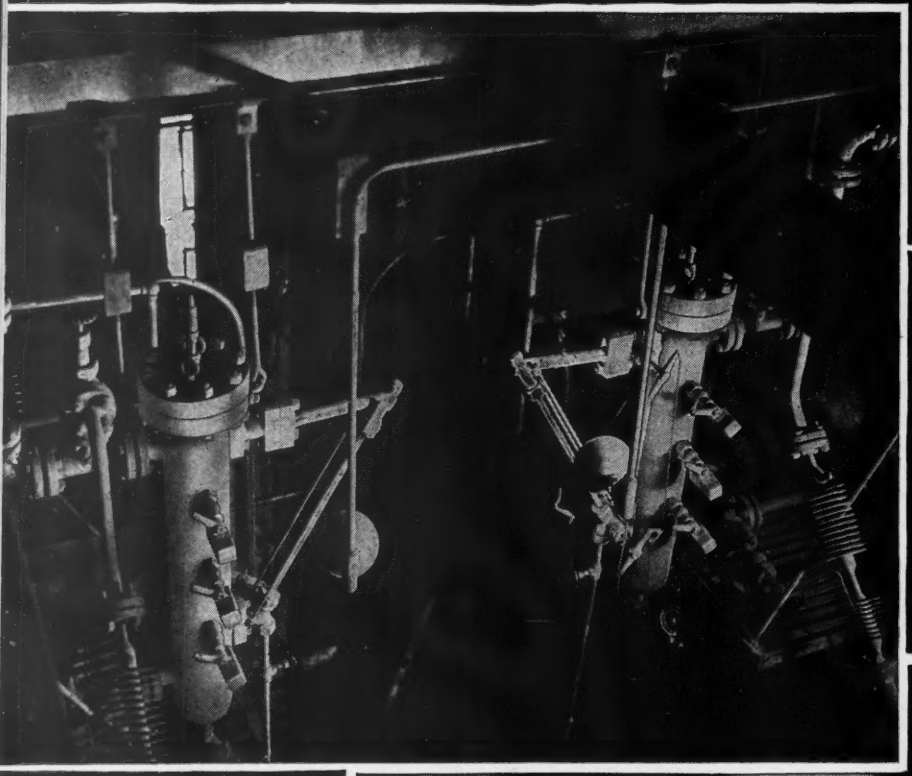
ARMSTRONG MACHINE WORKS

810 Maple Street **Three Rivers, Michigan**

STEAM TRAPS

Saving Fuel, Metals and Manpower for the Battle of Production

It's YARWAY



Left: Bird's-eye view of two of the three Yarway HI-LO Alarm Water Columns and Yarway SE-SURE Inclined Water Guges at the Bergstrom Paper Co. plant. These three boilers generate 2,000,000 lbs of steam every 24 hours.

Right: There are 48 Yarway Seatless Blow-Off Valves used in tandem—eight sets to each boiler—at the Bergstrom Paper Co. plant. These valves, operated every 12 hours, day-in and day-out, have totalled approximately eight thousand blow-downs in their fourteen years of faithful service.

YARWAY

All the Way at Bergstrom Paper Co.

YARWAY Seatless Tandem Blow-Off Valves, Yarway HI-LO Alarm Water Columns and Yarway SE-SURE Inclined Water Gages—that's the 100% Yarway score at the Bergstrom Paper Co. power plant at Neenah, Wisconsin. Worthy partners in protection of vital power facilities, especially today, when the utmost in efficiency is demanded of every plant.

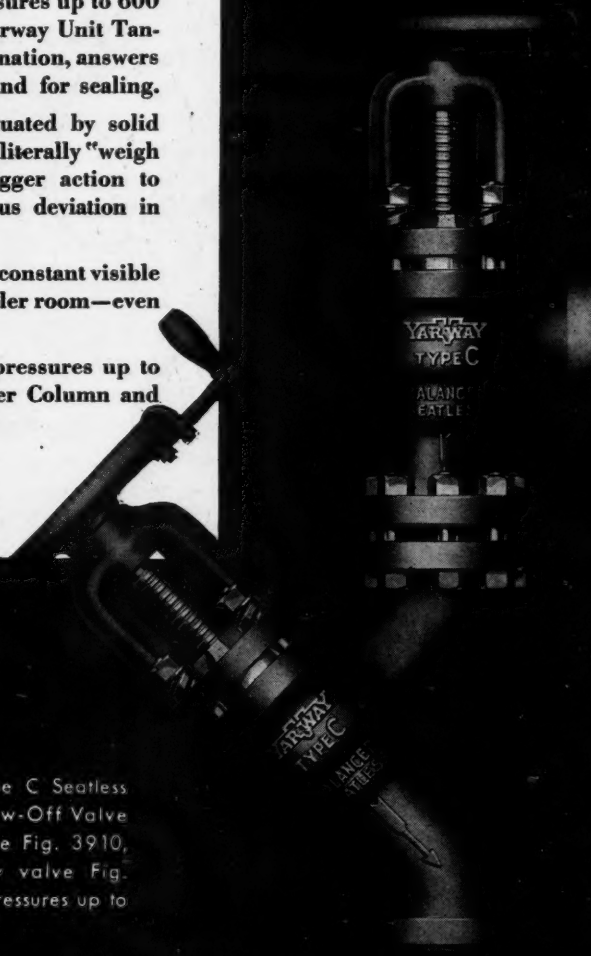
The positive sealing and long, trouble-free service of the Yarway Seatless Valve have made it the most widely preferred blow-off valve for boilers and water-walls operating at pressures up to 600 lbs. For higher pressures (up to 2500 lbs) the Yarway Unit Tandem, utilizing a hard-seat and seatless valve combination, answers all requirements for blowing-down or draining and for sealing.

The Yarway HI-LO Alarm Water Column actuated by solid weights operating on the displacement principle to literally "weigh the water level," gives instant, positive, hair-trigger action to warn by light, whistle, or both, of any dangerous deviation in normal water level.

The Yarway SE-SURE Inclined Water Gage gives constant visible indication of water level from any point in the boiler room—even directly beneath.

Write for Blow-Off Valve Catalogs B-421 for pressures up to 400 lbs; B-431 for pressures up to 2500 lbs; Water Column and Gage Catalog WG-1808.

YARNALL-WARING COMPANY
114 Mermaid Ave., Philadelphia



Yarway Type C Seatless Tandem Blow-Off Valve (angle valve Fig. 3910, straightway valve Fig. 3912) for pressures up to 600 lbs.

STEAM SPECIALTIES

. . . . THEY ENDED A

LUBRICATION NIGHTMARE

when they switched to

TYCOL STEAM CYLINDER OIL

In the words of one operator, "For the past six years we have been using Tide Water Cylinder Oil. During the entire period we have had no trouble of any kind with the engine. The troubles that once kept us on the run were eliminated six years ago." Another operator had this to say, "The trouble we had been having with our steam engine cleared up immediately when we changed to Tycol oils. Besides giving us better lubrication the lower consumption actually saved us 33⅓% of oil costs."

These men, like many others, have ended what were literally lubrication nightmares. Tycol Steam Cylinder Oil cured these troubles. This modern lubricant is made from 100% Pennsylvania crude. Its maximum chemical and physical stability, and flat temperature viscosity curve assure effective lubrication and sealing films with resulting economies.

Efficient lubrication assures untroubled engine performance for today's heavy production needs. If you're plagued by lubrication worries call in a Tide Water engineer. He will recommend the proper Tide Water lubricant "engineered to fit the job." Tide Water Associated Oil Company, 17 Battery Place, New York, N. Y.

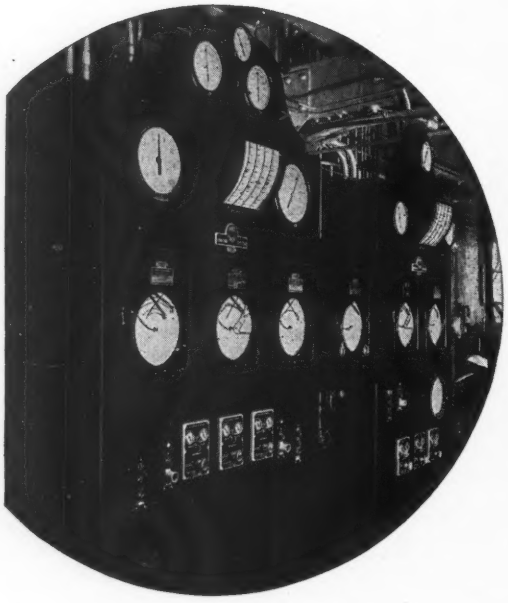
DRUMS! DRUMS! DRUMS! DRUMS!
War needs make it extremely important that all empty drums be returned immediately.

TYCOL

TIDE WATER ASSOCIATED OIL COMPANY
EASTERN DIVISION 17 BATTERY PLACE, NEW YORK
Regional Offices: Boston, Philadelphia, Pittsburgh, Charlotte, N. C.

MAKERS OF THE FAMOUS VEEDOL MOTOR OIL

ARMS FOR THE BATTLE OF PRODUCTION



★ This is a mechanized war. Battles are being won by hard-fighting men who are well armed with modern equipment.

In the battle of production the boiler operator whose effectiveness is multiplied by Bailey Meters and Control is like the machine gunner who rides to battle in a jeep, tank or airplane. Both men are better able to serve because they use modern arms.

To win the battle of production, boilers must be kept in almost continuous service, maximum capacities must be secured, fuel must be conserved, men and equipment must be protected against accidents, and new manpower must be trained.

Bailey Meters and Control are helping to win this battle. They are modern arms for boiler room soldiers. By their use power engineers are able to:

1. Avoid frequent shutdowns for maintenance.
2. Stretch steaming capacity.
3. Reduce consumption of fuel.
4. Insure safety of men and equipment.
5. Maintain efficiency while training new operators.

Their use is explained in the bulletin "How to Safely Stretch Steaming Capacity", which offers suggestions for the solution of many of today's problems. To obtain a copy simply ask for Bulletin No. 16. A-84-1

BAILEY METER COMPANY
1040 IVANHOE ROAD • CLEVELAND, OHIO
Bailey Meter Company Limited, Montreal, Canada

BAILEY METER CONTROL

The Complete Combustion Control System

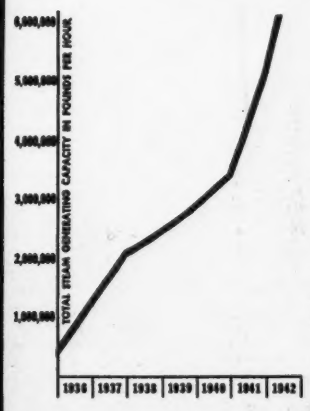
BOILER METERS • MULTI-POINTER GAGES • FLUID METERS • RECORDERS • SUPERHEAT CONTROL • DESUPERHEAT CONTROL • COMBUSTION CONTROL • FEED WATER CONTROL

WATER-COOLED STOKER SERVICE —NO MILITARY SECRET!

WATER-COOLED STOKER PICKED for RELIABILITY

Reliability was the Number 1 requirement for fuel burning equipment under consideration by an eastern central station. Greater assurance of reliability was forecast by Taylor Water-Cooled Stokers. Accordingly, the station purchased a 6-retort, 25-tuyere Taylor Water-Cooled Stoker for application to a 695 H.P. Boiler. The water-cooling elements of the stoker were extended up the front wall to provide economical cooling of the front wall.

Follow the Rise of Water-Cooled Stoker Sales



This chart tells you at a glance how power plant operators feel about the Taylor Water-Cooled Stokers. Many of the reasons for their enthusiasm are found in Catalog W, offered below. Why not send for it?

Read the Record

Stoker....Six-retort Taylor Water-Cooled 25QC9W...	Turbine Driven
Boiler....6,952 sq. ft.	Rear Water Wall
Date Unit went into service	May 2, 1940
Coal burned since starting date	16,926,144 lbs.
Water evaporated since starting date	187,956,000 lbs.
Average actual evaporation	11.10 lbs.
Average operating steam pressure	170 lbs.
Average operating steam temperature	375°F.
Average operating CO_2 at 35,000 lbs. per hr.	13.8%
Average flue gas temperature at 35,000 lbs. per hr...	500°F.
Average overall efficiency since starting up	82.1%
Number of times and total hours unit was taken out of Service as a result of stoker and stoker water-cooling system, inspection, cleaning and maintenance	4 times total of 8 days
Availability factor	97.7%
Load characteristics	Gradual variations of 10,000 lbs. to 48,000 lbs. with average of 22,400 lbs.
Maximum load carried for 4-hr. periods	48,000 lbs.
Coal	Island Creek, Logan County, W. Va. (Mine No. 22)
Material cost for stoker maintenance	None

Coal Analysis

Volatile matter	34.50%
Fixed carbon	57.00%
Ash	6.00%
Moisture	2.50%
Sulphur	0.45%
B.T.U. (as fired)	13,800
Ash fusing temperature	2,480°F.

Read What a User Has to Say

"Our experience on two 40,000 pounds steam per hour water-cooled stoker units for over three years has shown that—Reliability and freedom from breakdown is thus far more favorable . . . No tuyeres have been replaced as yet. Capacity or load demands have been rapidly met from minimum to maximum loads covered in the design.

"The flexibility of the water-cooled stoker has enabled us to successfully burn a very wide range of coals varying from the low through the high volatile range (17 volatile to 38 volatile). Consequently we can economically purchase our coal on a strictly B.T.U. basis, regardless of Ash Fusion Temperatures."

You Need All 3

Of the many ways Taylor Water-Cooled Stokers improve operation, three predominate: 1. Increased reliability. 2. Increased fuel flexibility. 3. Higher operating efficiency.

For an explanation of these advantages write for your copy of Catalog W. It contains useful information. Send in the coupon.

A-E-CO TAYLOR WATER-COOLED STOKER

AMERICAN ENGINEERING COMPANY
2408 Aramingo Avenue, Phila., Pa.

Send me without obligation a copy of the 8-page Catalog W describing Taylor Water-Cooled Stokers.

*Name*_____

*Company Name*_____

*Address*_____

*City*_____ *State*_____

The TERRY

TERRY
SOLID WHEEL TURBINE
ADVANTAGES . . .

— The blades and the wheel (see above) are in one piece so that there are no parts to become loose or work out.

— The blades have large clearances.

— The blades are double rim protected.

— End play will not damage the blading.

— It is impossible for the blades to foul.

— The power producing action of the steam in the wheel takes place on the curved surfaces at the back of the buckets and, therefore, close blade clearance is not necessary.

— As the only function of the blades is to form a series of pockets, wear of the blade edges is of little consequence and does not materially affect the horsepower or efficiency. The important part of the bucket is the back, or bottom, which is a solid forging.

— The Terry wheel will withstand abuse that would wreck any built up wheel.

THE TERRY STEAM TURBINE CO.

Wheel Turbine

The Terry Solid Wheel Turbine is available in ratings from 5 HP to 2000 HP. It is built for all commercial steam pressures and exhaust pressures. Thousands of them are in daily service in central stations, industrial plants and on board naval vessels.

Full details of the Terry Solid Wheel Turbine will be gladly sent upon request. Ask for Bulletin S-116.

At right—
Action of steam in Terry wheel turbine. The steam issues from an expanding nozzle at high velocity and enters the side of the wheel bucket in which its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is caught in a stationary reversing chamber and returned again to the wheel. This process is repeated several times until practically all of the useful energy has been utilized

T-1147

TERRY SQUARE - HARTFORD, CONN.

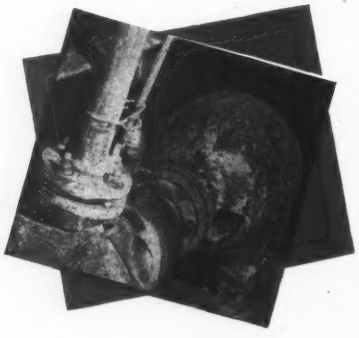
NEED MOTORS?

4 things to do

use standard, open, sleeve-bearing motors whenever possible . .

The standard Tri-Clad motor, though classed as an "open" motor, is so well protected that it gives good service on many jobs for which specially protected motors previously were recommended. (See below.)

Sleeve-bearing motors often can be supplied more readily than ball-bearing types because of the present demand for ball bearings on other war equipment. Use ball-bearing motors only on applications where load or mounting conditions definitely require them.



Special end shields and other modifications may result in delay for you and others doing war work.

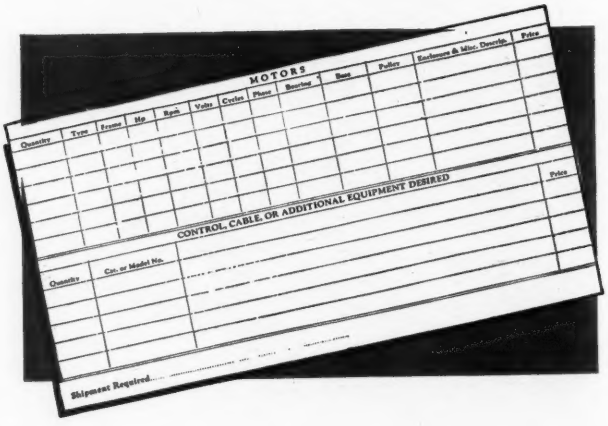
Consider the use of standard or multi-speed a-c motors in place of d-c wherever this alternative is possible.

order motors early . . giving complete specifications . .

Place motor orders when you order the machines they are to drive.

If you are planning motor drives for conveyors or other equipment for new plants, place orders as soon as design work indicates the motor requirements.

Avoid delay and "mix-ups" by giving complete specifications as shown in table below, preferably on an order form which your G-E motor representative can supply.



YOUR AID ON THESE 4 POINTS WILL HELP US PRODUCE AND DELIVER MORE MOTORS

YOUR CHOICE OF G-E TRI/CLAD MOTORS WILL GIVE YOU EXTRA PROTECTION AGAINST (1) PHYSICAL DAMAGE, (2) ELECTRICAL BREAKDOWN, (3) OPERATING WEAR.

WAR WORK?

to get them quicker

give complete priority information properly endorsed..

The filling of many motor orders is delayed because of incomplete priority information. If in doubt about details, call your local G-E office.

When placing orders for motors, be sure that complete priority data accompanies *each order* in the form of certificates, endorsements properly signed, etc. The priority is not effective in scheduling shipment until received by your supplier.

Your needs and the war effort are best served by using the proper priority rating as assigned by the War Production Board for the job involved and requesting delivery no earlier than actually required.

Builders of motor-equipped machines for subsequent sale may order their requirements in advance under the Production Requirements Plan.

check with G. E. for delivery from local warehouse stocks..

To meet urgent war needs, a supply of standard Tri-Clad motors is maintained at G-E factories and local G-E warehouses. Perhaps the motor you want, or can use with a few simple changes, is available for immediate shipment.

Your local G-E motor representative can furnish information on motors which may be in stock in the following cities:

Atlanta, Ga.	Los Angeles, Calif.
Boston, Mass.	Milwaukee, Wis.
Buffalo, N. Y.	Minneapolis, Minn.
Charleston, W. Va.	New York, N. Y.
Chicago, Ill.	Oklahoma City, Okla.
Cincinnati, Ohio	Omaha, Neb.
Cleveland, Ohio	Philadelphia, Pa.
Dallas, Texas	Pittsburgh, Pa.
Davenport, Iowa	Portland, Ore.
Denver, Colo.	St. Louis, Mo.
Detroit, Mich.	Salt Lake City, Utah
Houston, Texas	San Francisco, Calif.
Kansas City, Mo.	Seattle, Wash.

General Electric and its employees are proud of the Navy award of Excellence made to its Erie Works for the manufacture of naval ordnance.

Specify TRI-CLAD Motors

GENERAL ELECTRIC

how to make your ..with less outage and lower maintenance

If yours is one of the many plants operating chain grate or traveling grate stokers, here are some suggestions that will help you get longer life out of your present equipment and minimize outage for repairs or replacements. While they relate primarily to the two basic types of C-E stokers illustrated here, they are largely applicable to all chain and traveling grate stokers.

FOR PLANTS USING CHAIN AND TRAVELING GRATE STOKERS

If this information is not of immediate interest to you, please see that it reaches the proper man in your organization.

OPERATION

GENERAL The two main causes of excessive outage and maintenance are **(1)** sustained or frequent overloading of stoker and **(2)** operating with insufficient draft resulting in positive furnace pressure.

Where prolonged overloading is unavoidable, as is often the case in these days, good operation and careful attention to maintenance are especially important. Frequently, in such cases, the use of a higher quality coal will make it possible to carry the increased load without excessive outage or maintenance costs.

Where difficulties are due to insufficient draft, the suggestions made under the heading "Draft" may prove helpful.

FIRE **(1)** Determine by experimental operation the correct fuel bed thickness, grate speed and compartment air pressures for specific conditions of coal, capacity and furnace setting. Readjust promptly whenever a different fuel is supplied to the stoker. In general, fuel bed should be relatively thin; grate speed relatively fast. Some margin of grate speed should always be reserved for emergency condition.

(2) Keep an even fuel bed thickness across the full width of the stoker. An uneven feed or fuel bed upsets air distribution, causes fuel bed to burn out unevenly, permits overheating of sections of the grate surface and usually results in high ash pit losses.

(3) Where a low-set waterback is used at the rear of stoker, do not permit fuel to pile up at that point. Serious overheating of grate beneath may result.

(4) Keep an ample supply of coal in hopper—not less than half full—at all times during operation. Avoid segregation of coal sizes in hopper. Wherever possible use mechanically-operated swinging spout, traveling larry or non-segregating spreader chutes.

(5) Do not permit too much ash to accumulate in ash pit. Hot ashes close to rear of stoker may cause warping of grate surface and rear shaft. Keep ash pit doors tight. Serious air leakage to furnace may occur at this point, causing an increase in the preventable fuel loss.

(6) Serious damage may result from improper procedure in banking a stoker. Type of stoker, design of furnace and character of coal determine the proper method of procedure. Because of these variables, the space available here does not permit detailed instructions. However, it is a good general rule never to bank a hot fire—always burn down first. Information on proper banking procedure will be supplied by the stoker manufacturer on request.

DRAFT **(1)** Operate with slight draft just above fuel bed. Plus pressure will cause excessive temperatures at grates and lower wall areas.

(2) Maintain proper supply of air at all times. Either too much air or too little air will reduce efficiency and capacity.

(3) Some air should be allowed to pass through grates at all times except when fire is banked.

(4) Don't force stoker beyond capacity of stack to carry away gases.

(5) See that stoker dampers and their operating mechanisms function properly. Check air seals occasionally to be

C-E PRODUCTS INCLUDE ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS, AND AIR HEATERS

COMBUSTION

stokers last longer

sure there is no leakage.

(6) If boiler draft is insufficient, check setting and flue for leaks; also position and operation of boiler damper. Some improvement is usually possible.

CLEANING (1) Remove siftings from air and sifting compartments *regularly* to avoid any possibility of fire under grate. Where steam ejectors are used, drain lines frequently to assure dry steam.

(2) Keep stoker exterior clean to prevent contamination of lubricants and excessive wear on moving parts.

INSPECTION & MAINTENANCE

(1) Inspect all accessible parts of stoker daily, and examine stoker completely when shut down—at least twice yearly.

(2) Replace broken grate elements promptly to prevent excessive sifting loss. Allow clearance between grate elements when assembling to avoid damage due to their natural growth under heat.

(3) Operation with distorted grate bars or rods may cause extensive damage.

(4) Badly worn grate bar ends and driving chains, burned ledge plates, or the combination of these conditions, can cause excessive air leakage along the grate line. The resulting "blow-torch" action is very destructive to parts in this area.

(5) Check wear on chains and sprockets frequently. Reversing them when badly worn prolongs their useful life. Proper chain tension should be maintained by adjusting "take-up" regularly. See that chains engage sprockets correctly and advance evenly to avoid rapid wear.

(6) Check gate tile and their supports regularly. Replace promptly when burned or warped to assure even fuel bed thickness.

(7) Inspect drive mechanism occasionally for wear on gears, condition of bearings, alignment and lubrication.

(8) Check alignment of shear coupling occasionally to be sure that it functions properly. Never use makeshift shear pins. If standard shear pins fail, determine cause of overload.

(9) Inspect return rails when possible. Replace badly worn wearing strips promptly.

LUBRICATION Lubricate all points requiring lubrication on a definite schedule. Use the correct grade of lubricants. Give particular attention to the drive mechanism. Flush and clean gear case at least once a year. Refill to correct level with new oil of proper grade. Adequate lubrication is inexpensive insurance against outage and excessive maintenance.

C-E TRAVELING GRATE STOKER—Typical installation view of the Coxe (bar type) Stoker. Unequalled for burning the small sizes of anthracite and coke breeze; also well suited to lignite and some free-burning bituminous coals. Approximate application range is from 150 rated boiler hp up to units producing 200,000 lb or more of steam per hr.

C-E CHAIN GRATE STOKER—Installation view of forced-draft chain grates; also built in natural draft designs. Particularly well-suited to the use of free-burning bituminous coals. Approximate application range is from 150 rated boiler hp up to units producing 275,000 lb of steam or more per hr.

The C-E line of stokers is the most extensive on the market. It includes single retort, multiple retort, spreader, traveling and chain grate types.

OVER 17,000 C-E STOKERS HAVE BEEN PURCHASED TO DATE

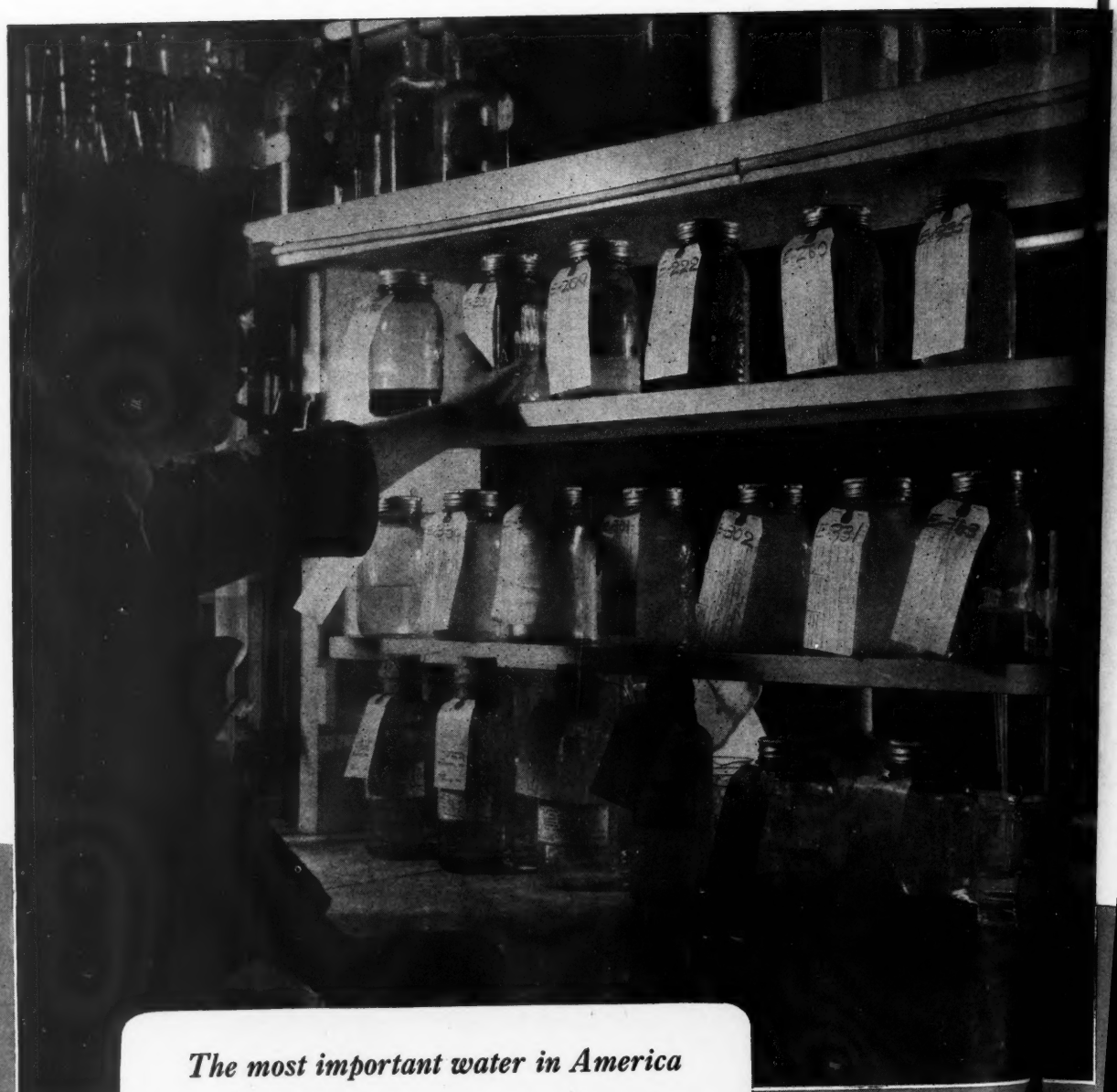
Reprints of this advertisement on heavy paper available on request

COMBUSTION ENGINEERING COMPANY, INC., 200 MADISON AVENUE, NEW YORK, N.Y. • CANADA: COMBUSTION ENGINEERING CORPORATION, LTD., MONTREAL

COMBUSTION ENGINEERING

A-869

This is no time to mince words



The most important water in America

Boiler water samples from a large army tank builder, four of the Nation's biggest steel mills, a large chemical plant, a major rubber company, a munitions manufacturer and other war plants. These steam plants and hundreds of others are producing 24 hours a day at top capacity with the aid of Hall Service.

over boiler water service!

Steam production is too vital to the war effort to rely on half-way measures

NO part of your equipment is more important to you today than that which produces your power. None is driven harder or put to more severe tests. None would probably be more difficult to replace. Coddle it. Conserve it. But for victory's sake, if trouble does arise, don't trust its correction to half-way measures. Don't experiment. Don't guess.

Half the boiler outages we are called on to correct needn't have occurred. Half the repairs and replacements can be traced to incorrect diagnosis of their cause. They occur because there isn't a preventive specialist on the job.

What preventive measures are you taking against the four major enemies of steam production . . . Scale — Corrosion — Carry-over — Embrittlement?

Here's one thing leading steam producers have found it profitable to do—investigate Hall Service. For it offers what might be called "preventive medicine for boiler plant ills" in the most complete and practical form possible to obtain, a service which has *nothing* to sell but knowledge . . . the "know how" to keep boilers on the line.

The men who head the Hall organization are the men who contributed so much to the basic principles of sound water conditioning . . . the men who did the pioneering in this field . . . the men of whose work it may be truly stated that *there is no boiler plant in operation today that has not in some manner benefitted by their research.*

Thousands of case histories of industries served by Hall Laboratories offer a collection of facts and experiences that cannot possibly be equalled. Hall clientele is a Blue Book list of hundreds of the most important plants in the country.

Too much of the victory effort depends upon the maintenance of production . . . too much depends upon your own plants' production to mince words over the vital question of water conditioning service. Unless you are sure you have the best you can obtain . . . that it is *unquestionably* scientific and practice-proven, it is not good enough for you in times like these.

If there is one thing you want today, it is to be ready with *plenty* and *in time* to meet the problems of steam production under trying conditions. We would be glad for the opportunity to show you how Hall Service can provide it.

HALL LABORATORIES, INC. · HAGAN BUILDING · PITTSBURGH, PA.

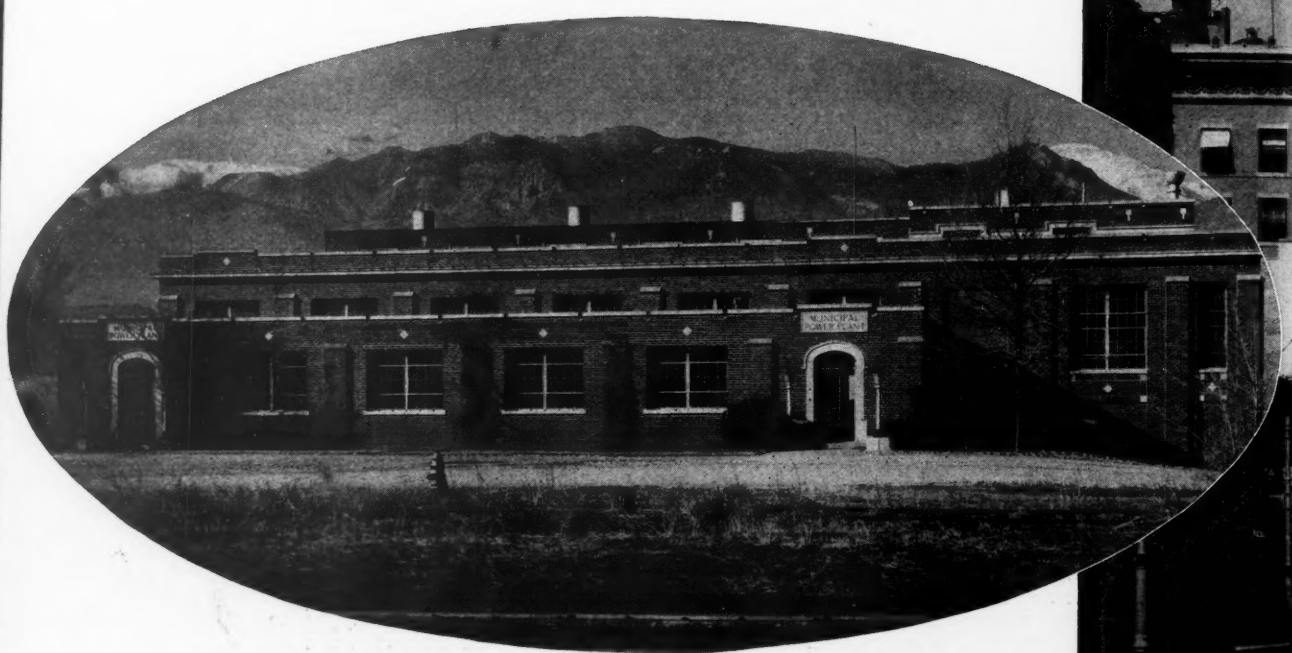
HALL SERVICE IN A NUTSHELL

At your immediate disposal are placed the technical knowledge and facilities of the pioneering leaders in scientific boiler water conditioning. In addition, with your full co-operation, Hall Service:

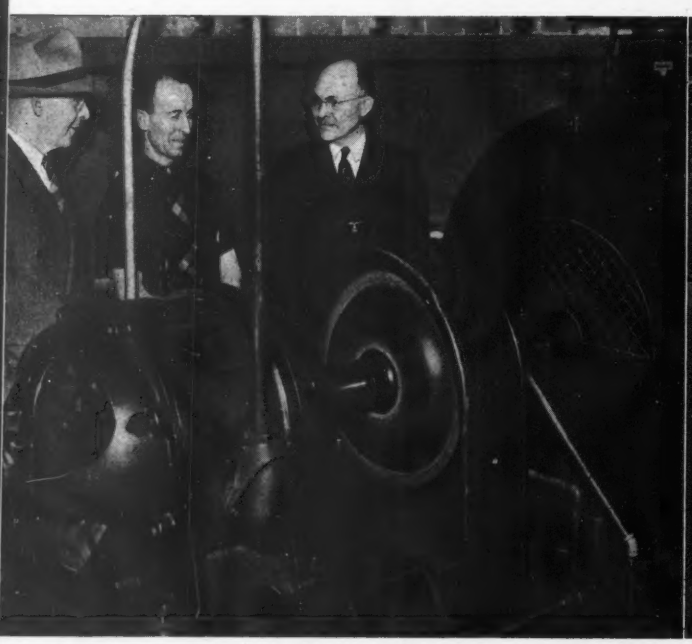
1. **Minimizes boiler outages caused by water.**
2. **Helps maintain highest efficiency.**
3. **Establishes non-embrittling water.**
4. **Minimizes carryover.**
5. **Prevents corrosion in boilers and associated equipment.**
6. **Prevents deposition in water lines and cooling systems.**

HALL SYSTEM *of Boiler Water Conditioning*

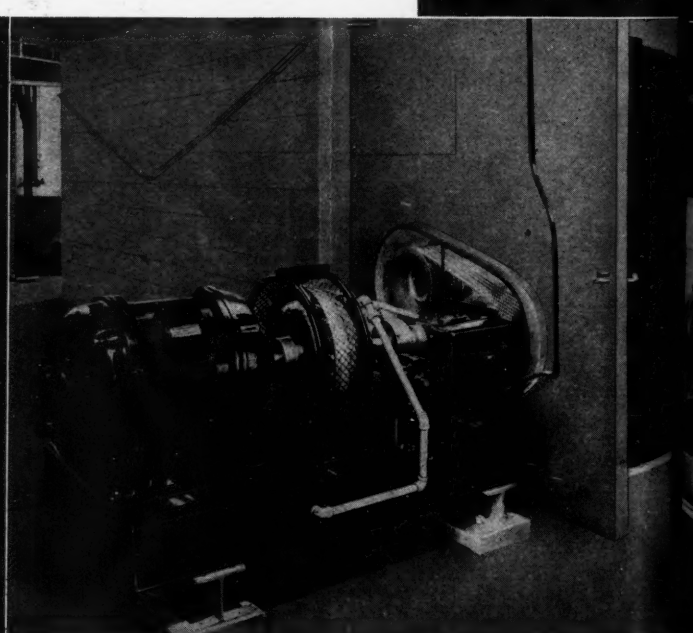
COLORADO SPRINGS



Above—The modern generating station that supplies electric power for Colorado Springs, Colorado. At right—View in downtown Colorado Springs, with Pike's Peak in background.

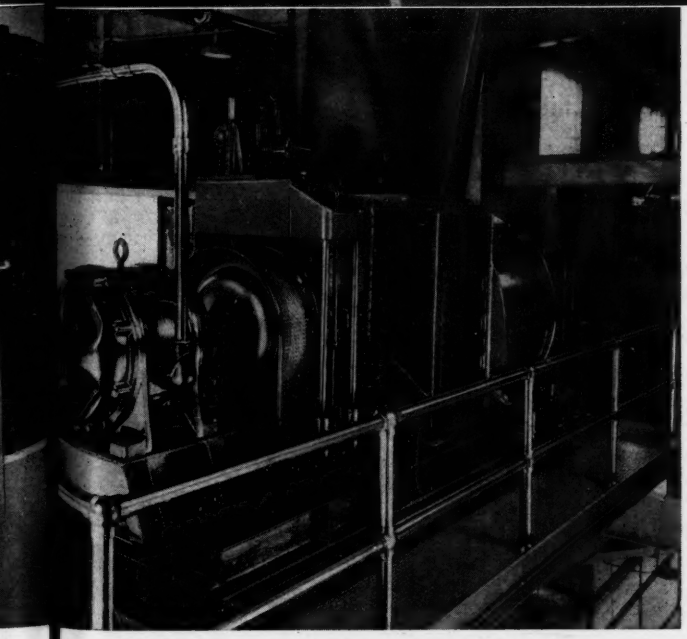


AMERICAN BLOWER Forced Draft Fan driven through an American Blower Fluid Drive (Hydraulic Coupling) in the electric generating station shown above.



THIS V-BELT DRIVE arrangement of an American Blower Forced Draft Fan driven through an American Blower Fluid Drive was pioneered in Colorado Springs.

Sitting Pretty



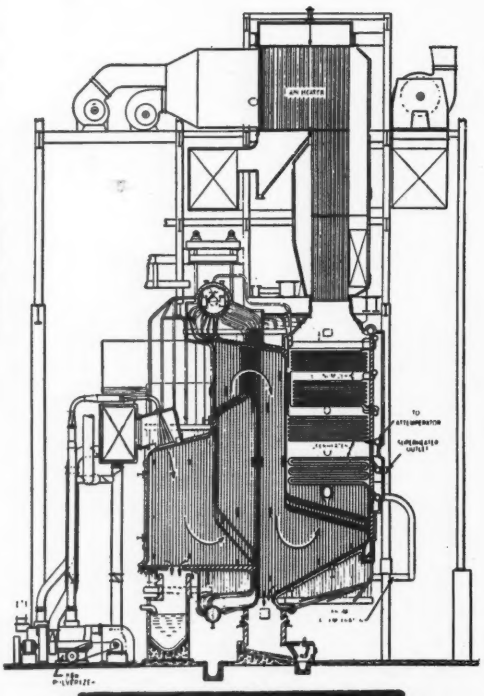
AMERICAN BLOWER Induced Draft Fan, driven through an American Blower Fluid Drive. Write to the nearest American Blower branch office for complete data.

Colorado Springs, famous health and pleasure resort, financial center and market for the Cripple Creek gold field, important distributing point for Colorado mined coal, has been "sitting pretty" for a long time. A "young" city, incorporated in 1872, Colorado Springs was quick to utilize the modern aids to civic progress . . . by no means least among these, electric generating facilities capable of supplying abundant, dependable, electric power to meet all the needs of the community. American Blower Forced and Induced Draft Fans are functioning in the modern plant that supplies this power. And the plant is 100% American Blower Fluid Drive (Hydraulic Coupling) equipped — a fact that makes us doubly proud!

AMERICAN BLOWER

AMERICAN BLOWER CORPORATION, DETROIT, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO
Division of American Radiator and Standard Sanitary Corporation

Not the number
-but the Job each



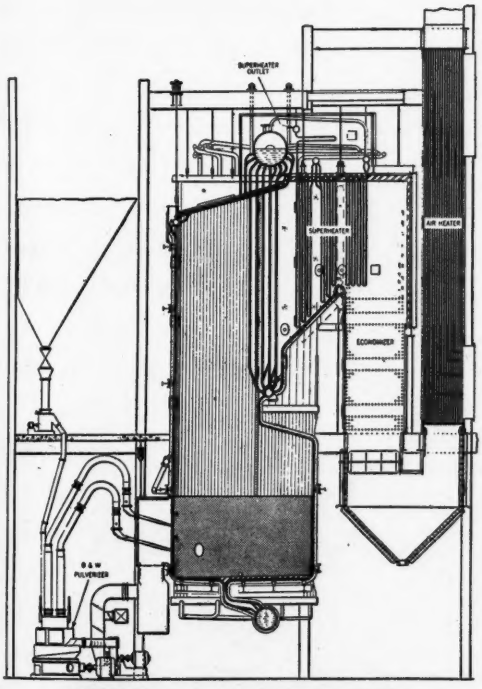
OPEN-PASS BOILER

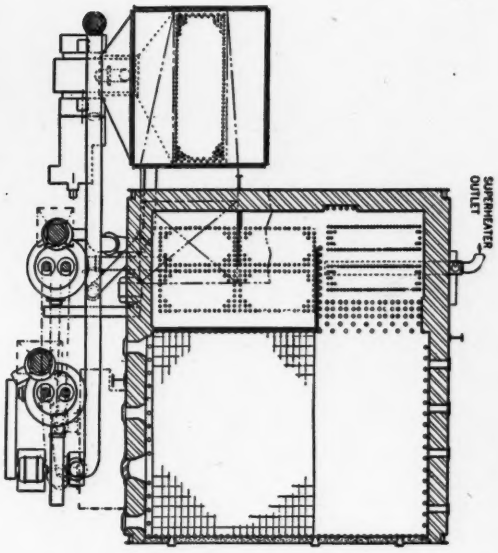
B&W is naturally proud of the statistics covering the Radiant, Open-Pass, and Integral-Furnace Boilers sold in 1941 for central-station service, which, for example, show that 71 per cent were purchased by utility companies already having boilers of these designs in service or on order—definitely indicating the acceptance of these designs. Twelve of the boilers will have individual steam-generating capacities of 500,000 lb. per hr. and over, thirty-five are designed for pressures of 900 psi or higher, and thirty-two for total steam temperatures of 850 F. or above.

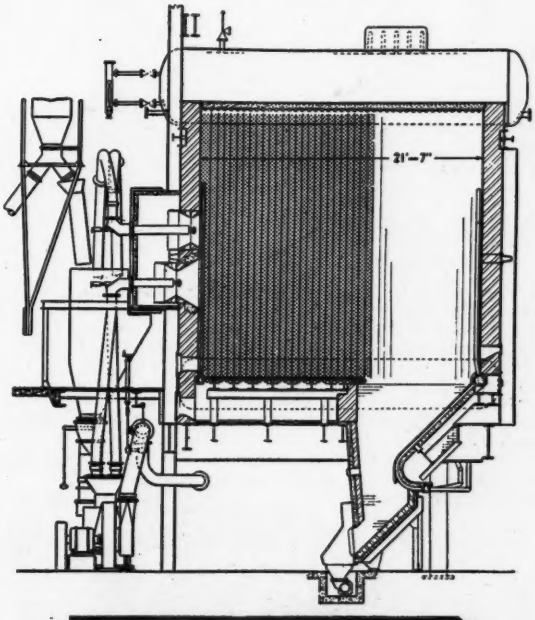
But greater pride is taken in the fact that each application is a pointed example of the adaptability of B&W designs to exacting central-station requirements, through the use of existing designs, the adaptation of an existing design, or the creation of a new design to meet specific engineering problems. And into each is built the broad experience of the B&W Company—experience impossible to write into specifications or to show on blueprints, but is inherent in all B&W Boilers.

THE BABCOCK & WILCOX COMPANY
85 LIBERTY STREET, NEW YORK

r and size
n will do





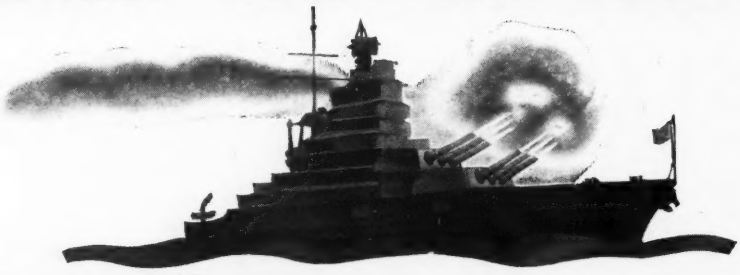


The Navy "E" Award to the Barberton Works for production achievement is "an honor not lightly bestowed and one to be cherished."

BABCOCK & WILCOX

G-217T

New Armor-Plate...and Back on Duty



APEXIOR ON OLD BOILER METAL GUARDS IT FOR THE DURATION

American vessels, badly damaged at Pearl Harbor and in the South Seas — "destroyed", according to the enemy — are already back in service, repaired, rearmored, fit for duty.

And plenty of steam boiler equipment, thought ready for the bone-yard, has been cleaned up, given APEXIOR'S armor-plate protection against wear and corrosion, and recalled to active service.

Make sure *now* that every tube and drum in your plant will be on duty for the duration . . . you *can't get* replacements. If your boiler, when cleaned to bare metal, comes through the required hydrostatic test, APEXIORIZE, and with reasonable care it is good for years.

APEXIOR — Impenetrable Armor-Plate against Corrosion and Wear

You put it on with a brush — hand or power-rotary. The chemically inert, tough protective coating fills and seals all joints, pores and surfaces, rendering boiler metal immune to corrosive penetration, resisting the erosion that would wear bare metal down.

Water scale, if any, adheres loosely, for there can be no direct, chemical bond. Off it comes by wire-brushing.

In 2 or 3 or more years, APEXIOR will wear thin. Simple, single-coat renewal then restores its original protection.

★ ★ ★ ★ ★ ★ ★ ★

APEXIOR Guarantees Good Metal Condition — no other protection offers the same assurance and security

For years, wise engineers have used APEXIOR NUMBER 1 as insurance of efficiency and good boiler housekeeping — supplementing proper feedwater treatment.

Now, this precaution becomes essential.

Recommended by all U. S. & Canadian boiler insurance companies.

Write for Bulletin 1290

APEXIOR
REG U.S. PAT. OFF.

THE DAMPNEY COMPANY OF AMERICA

PROTECTIVE COATINGS FOR STATIONARY BOILERS, LOCOMOTIVES AND STEAMSHIPS

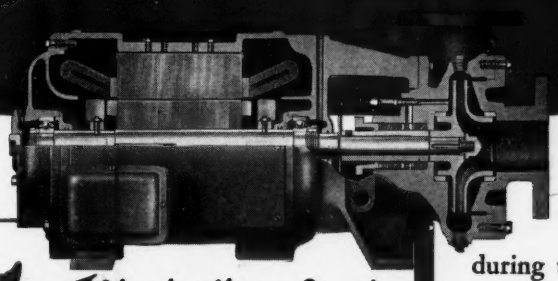
HYDE PARK · BOSTON · MASSACHUSETTS

Atlanta Chicago New York Detroit Philadelphia

Engineering Sales Representatives — Pittsburgh, Cincinnati, New Orleans, San Francisco, Los Angeles, Portland, Seattle, Phoenix, Denver, Salt Lake City, Dallas, Houston, Vancouver, B. C., Montreal, P. Q., Havana, Cuba, Manila; P. I., Honolulu, T. H., Marine Dept., 114 Liberty Street, New York, N. Y.

5 REASONS WHY

Here Are 5 Big Reasons Why the New Allis-Chalmers "One Package" Electrifugal Pumps Are Better Able to Serve You Through the War Years . . . and for Years Beyond!



✓ Check These Great One-Package Features

1. *Up to 33% Space Saved* with one frame, one solid driving shaft construction.
2. *Overhang Cut as Much as 40%.* Four solid supports assure precision balance . . . ease strain on vital parts.
3. *New Tri-Fit Design* eliminates 2 section fits for more positive shaft alignment, wearless and vibration-free performance.
4. *Splash-proof* Motor standard equipment—100% designed for pumping.
5. *Easy-to-Get-at* Casing simplifies stuffing box and waterseal gland inspection.

WHEN YOU BUY pumping equipment in wartime, it means — (1) getting top efficiency during the war emergency, and (2) getting longer life and increased economy for the post-war years ahead!

That's why you should know the full story about Allis-Chalmers' new "one-package" Electrifugal Pumps. For here's a line of pumps that are new all the way through — new in design . . . new in construction . . . new in performance.

Listed at left are "5 Reasons Why" these pumps are able to give you this new kind of service. They are important reasons, every one of them. They represent the type of design engineering that makes these pumps the most popular new pumps on the market.

Important, too, is the fact that you can get these new pumps in sizes from ½ hp to 25 hp.

For full details, call the pump engineer in the district office near you. Or write Allis-Chalmers, Milwaukee, Wis.

A 1541

ALLIS-CHALMERS
MILWAUKEE·WISCONSIN

WE PLAN FOR VICTORY WE PLAN FOR PEACE

TO WIN BATTLE OF PRODUCTION IS *your* DUTY

Four ways ELGIN PRODUCTS can help

1

ELGIN "DOUBLE-CHECK" PRINCIPLE applied to your present water softener practically double its efficiency.

- Increases water softening capacity as much as 44%.
- Prevents loss of zeolite.
- Cuts salt consumption.
- Stops packing and channeling of zeolite bed.
- Improves backwashing, making softeners self-cleaning.

[New Elgin "Double-Check" Type Softeners are built on this principle]

FACTS IN BULLETIN 605

2

ELGIN CHEMICAL TREATMENTS individually formulated to protect and prolong life of equipment include:

- Boiler water treatment.
- Process water treatment.
- Hot water treatment.
- Cooling water treatment.
- General cold water treatment.

Testing Equipment

[*Water analysis and Consultation Service—without charge*]

FACTS IN BULLETIN 550

3

ELGIN HEAT EXCHANGERS

(Continuous Blowdown Systems for boilers) save fuel; step up efficiency.

- Maintain correct soluble concentration of boiler water for production of clean dry steam.

- Assure uniform blow down rates despite wide variations in boiler load — eliminating large wasteful blowdowns at peak loads.
- Save fuel by increasing feed water temperature.

FACTS IN BULLETIN 510

4

ELGIN DECONCENTRATORS keep boilers in efficient operation and cut steam production costs.

- Keep boilers free of mud, sludge and scale.
- Cost less to install because less material is required.
- Eliminate the necessity of expensive auxiliary equipment.
- Complete the water conditioning job by removing residual hardness and after precipitations where lime-soda softeners are in service.
- Easy to operate—require minimum space—applicable to a wide range of conditions.

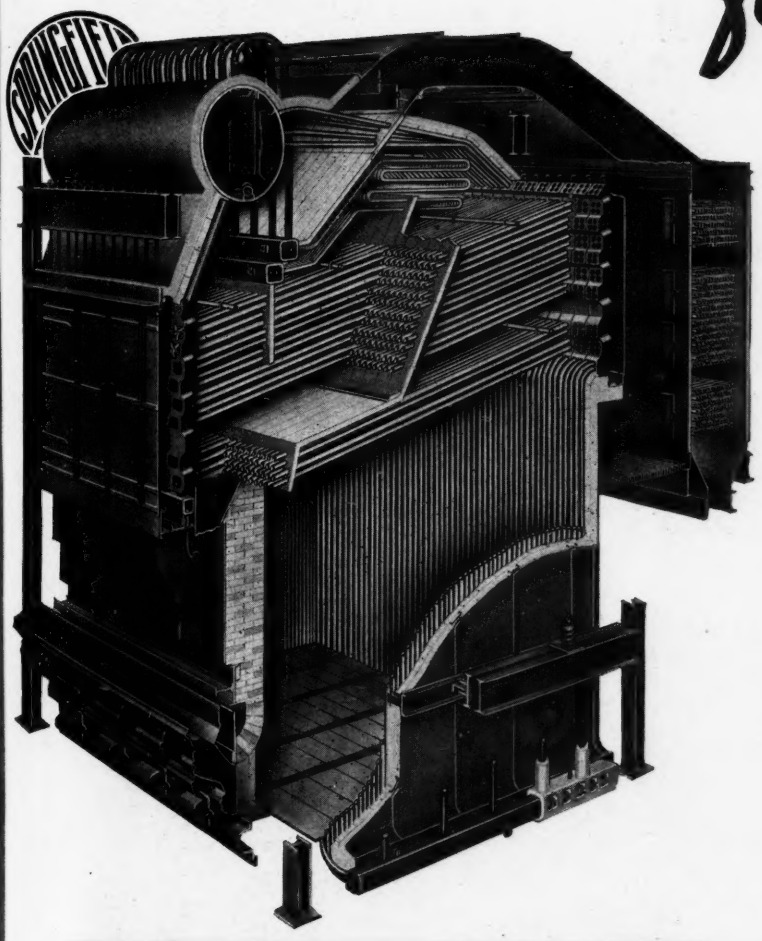
FACTS IN BULLETIN 500

ELGIN SOFTENER CORPORATION, 136 North Grove Avenue, Elgin, Illinois

WATER CONDITIONING PRODUCTS

FEATURES THAT SAVE TIME!

30 to 60 Days Earlier Completion for War Plants!



ACTUAL records on recent war plant boiler installations reveal that Springfield's design and method of fabrication and erection has cut from 30 to 60 days off the time commonly required for completion of the boiler installation. This important advantage is made possible by several factors.

★ **SHOP ASSEMBLED SECTIONS.** Sections of 3" tubes rolled into rugged electric cast steel headers are assembled complete with baffles in our shop saving weeks or months in field construction time, depending on the size of the units. Water walls are also shop assembled where field conditions permit.

Each section is hydrostatically shop tested and inspected at pressure at least 50% over working pressure and never less than 500 lbs. Springfield's distinctive 4-tube grouping arrangement, combined with the sinuous headers gives each section rigidity and strength to withstand handling in shipping and in the field. Valuable time and labor savings, particularly on shipments going into overseas locations.

★ **COMPLETE 90% OF INSTALLATION BEFORE DRUM ARRIVES.** Delays in getting steel plates for drums is a minimum retardant on Springfield jobs. The setting can be put in, tubes, headers, water walls, auxiliaries installed—all before the drum arrives for connection.

★ **SINGLE DRUM.** A minimum amount of steel plate is diverted from shipbuilding and other urgent uses when the Springfield design is used. Cast steel, the material selected for turrets and hulls of newest Army tanks, has long been used by Springfield to produce better headers for boilers and water walls. With one size of straight boiler tube, Springfield averages about 1/16 fewer tube sizes than common bent tube boilers.

★ **DELIVERY.** Springfield shops are not loaded up with mass production of standardized boilers. Immediate attention can be given to units to meet the most special needs. Write, phone or wire for quotations. SPRINGFIELD BOILER CO., 1951 E. Capitol Ave., Springfield, Ill.

DUPLICATE UNITS

COMPLETE drawings, patterns, shop fixtures, etc., are on hand to duplicate any of the many modern Springfield steam generating units built in recent years. Capacities from 5,000 lbs. to 450,000 lbs. per hour, or more. Pressures from 75 lbs. to 750 lbs., or higher. Springfield regularly takes contracts for complete steam generating units.

SPRINGFIELD

STEAM GENERATING UNITS

SPRINGFIELD BOILERS

ANY SIZE
ANY FUEL
ANY PRESSURE

How Swartwout Feed Water Regulation Responds to Sudden Load Fluctuations

—such as you may experience in BLACKOUTS

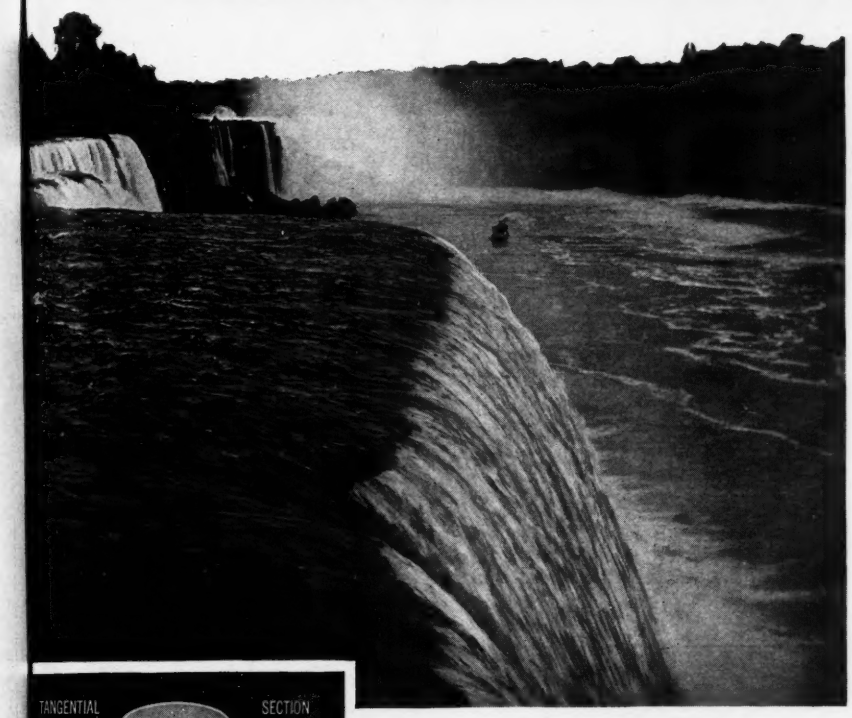
CUT POWER, *suddenly,* 2000 kilowatts at a time. Then restore the load, *suddenly.* Do the same with *8000 kilowatts.* How will your feed water regulation respond to this gruelling job? Here are the results (see charts) of tests run by the operating crew (*no manufacturer's experts on hand*) of a plant equipped with Swartwout Two-Element Feed Water System, serving a boiler working at about 850 pounds. Boiler feed furnished by motor-driven pump — uncontrolled. Note particularly the bottom chart — "Level."

• Swartwout two-element feed water regulation employs the same simple dependable principles as the "S-C" Regulator, with no intricate mechanism to get out of order. Automatic, or manually operated (auxiliary air) when desired, with manual control on main panel. Details gladly supplied by

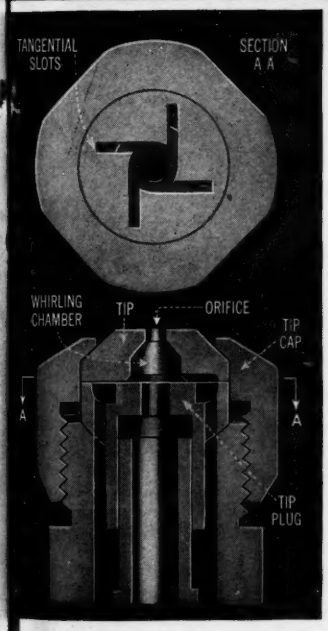
THE SWARTWOUT COMPANY
18541 Euclid Avenue • Cleveland, Ohio

Feed Water Regulators • Pump Governors • Feed Water Heaters
Master Controls • Reducing Valves • Separators • Exhaust Heads
Swartwout
•Power Plant Equipment•

CONSTANT PRESSURE DROP



The Secret of
FINE ATOMIZATION
in the
PEABODY
CD WIDE RANGE OIL BURNING SYSTEM

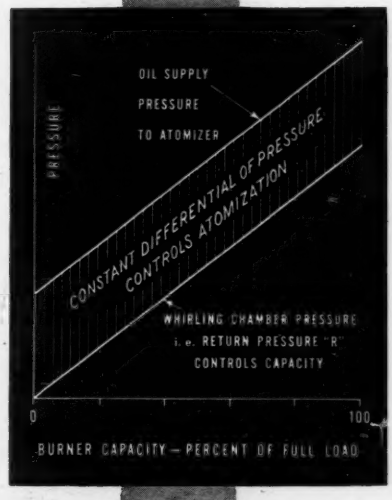


Tip Section of PEABODY Wide Range Oil Atomizer

NO MATTER whether much or little water flows over Niagara Falls, the "drop in pressure head" remains constant, creating the clouds of vapor and mist that are always present in the canyon.

This same principle has been incorporated in the Peabody CD (Constant Differential) Wide Range Oil Burning System, to deliver finely atomized oil to the boilers at any rate of firing, from zero to full load. In the Wide Range System, fineness of spray is dependent solely upon the speed of oil rotation in the burner tip whirling chamber, which is a function of the pressure drop across the tangential slots and the viscosity of the liquid.

The Peabody CD Wide Range System is the one certain means of assuring perfect combustion in plants with varying load requirements. It can be installed with Peabody Wide Range Burners built to fire oil only or oil, gas and pulverized fuels combined. No firing equipment gives greater flexibility in choice of fuels and operating range. That is why you should equip your plant with Peabody Burners.


OIL SUPPLY PRESSURE TO ATOMIZER
PRESSURE
CONSTANT DIFFERENTIAL OF PRESSURE CONTROLS ATOMIZATION
WHIRLING CHAMBER PRESSURE i.e. RETURN PRESSURE "R" CONTROLS CAPACITY
0
100
BURNER CAPACITY — PERCENT OF FULL LOAD

The Pressure Drop Between Atomizer Supply and Return Oil Lines Remains Constant Throughout the Full Burner Capacity Range

PEABODY ENGINEERING CORPORATION

580 FIFTH AVENUE • NEW YORK

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BOSTON
CHICAGO
CLEVELAND
DENVER
DETROIT
EAGLE PASS (Tex.)
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NEW ORLEANS
PHILADELPHIA
PORTLAND (Ore.)
ST. LOUIS
ST. PAUL
SAN FRANCISCO
SEATTLE

BUENOS AIRES • MEXICO CITY • MONTREAL

PEABODY LIMITED, LONDON

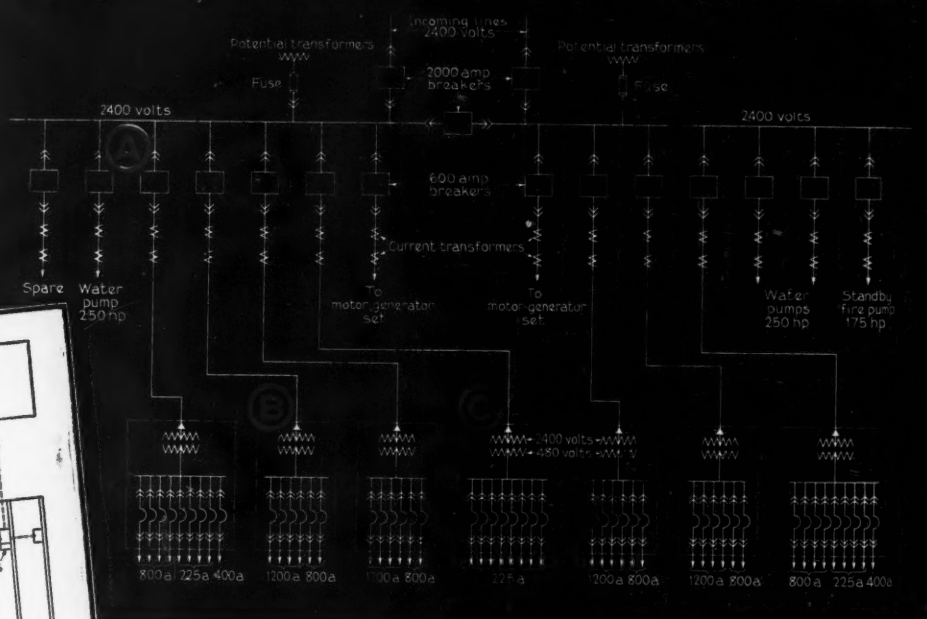
SEE HOW "one-line action"

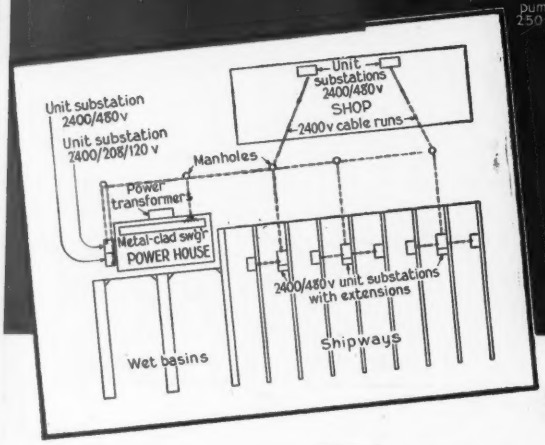
"Just give us a simple one-line diagram and we'll go right to work on standard equipments."

— from a recent General Electric advertisement

GOT THIS WAR PLANT ROLLING MONTHS SOONER

This one-line diagram got action. It enabled us to start work immediately on standard distribution equipments for the large war project sketched below. On the opposite page are views of the equipments, installed.





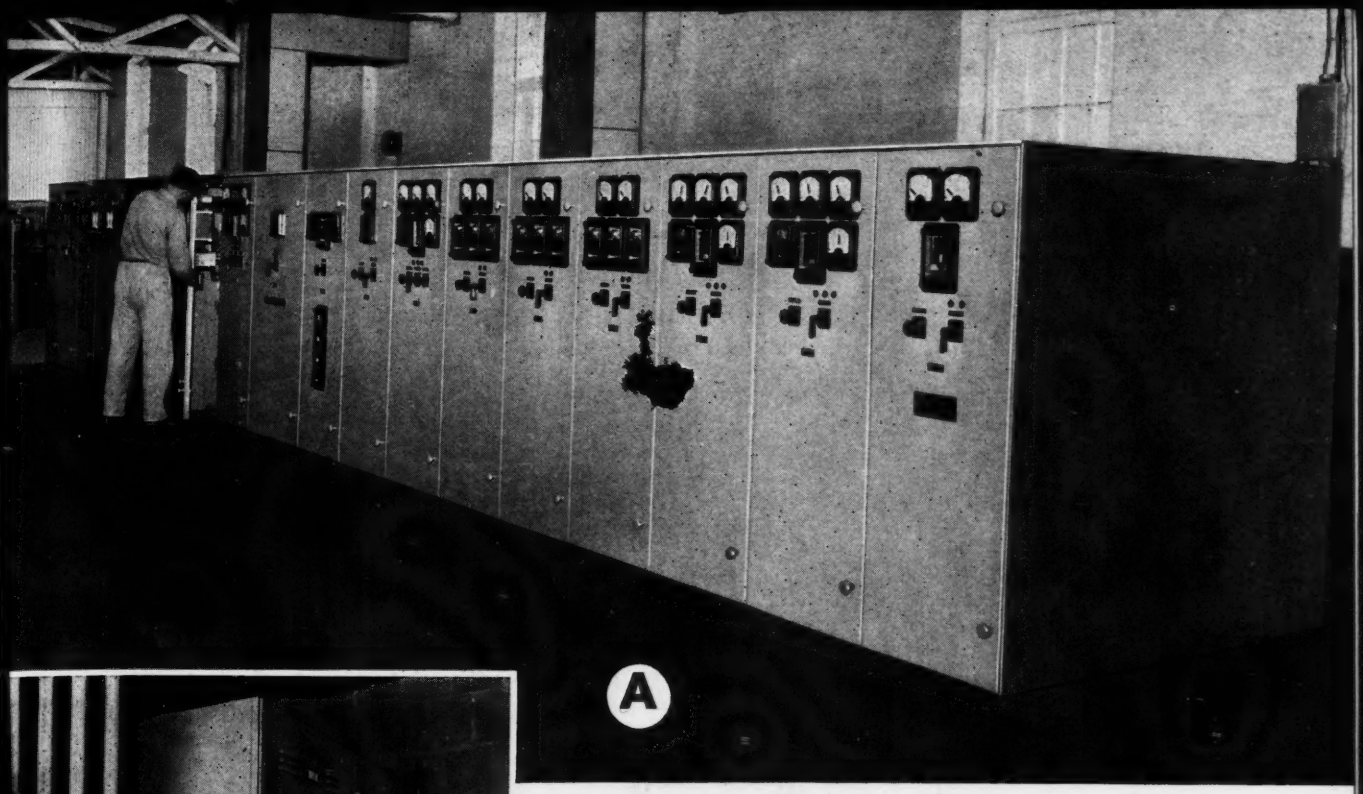
Saved Months — and 145 tons of copper

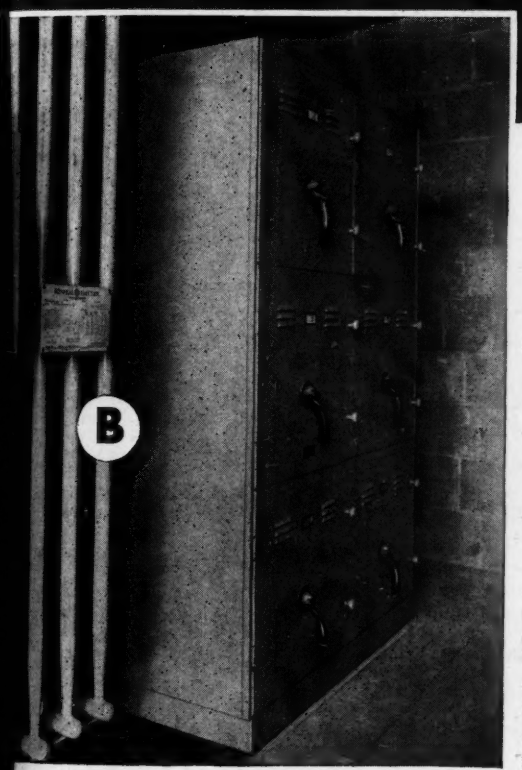
THEY Used Load-center Distribution— High-voltage power goes right to load-center unit substations, from where it is distributed directly to the loads through *short*, low-voltage secondaries. This reduced the amount of cable copper to *one-seventh*— saved more than 290,000 pounds of hard-to-get copper.

They Used Standard G-E Equipments— Standard G-E metal-clad switchgear equipments and unit substations were ordered at an early stage of construction. These "packaged" units arrived at the job when needed, and were installed quickly and easily. The safety metal-enclosed construction protects personnel and gives extra assurance of service continuity.

Standard G-E load-center units will get your machines rolling months sooner than is possible with nonstandard equipments, with tons less copper and other war-vital materials. Ask the nearest G-E office for additional information. ***General Electric Company, Schenectady, N. Y.***

The Navy "E", for Excellence, has been awarded to 92,780 General Electric employees in five plants manufacturing naval equipment

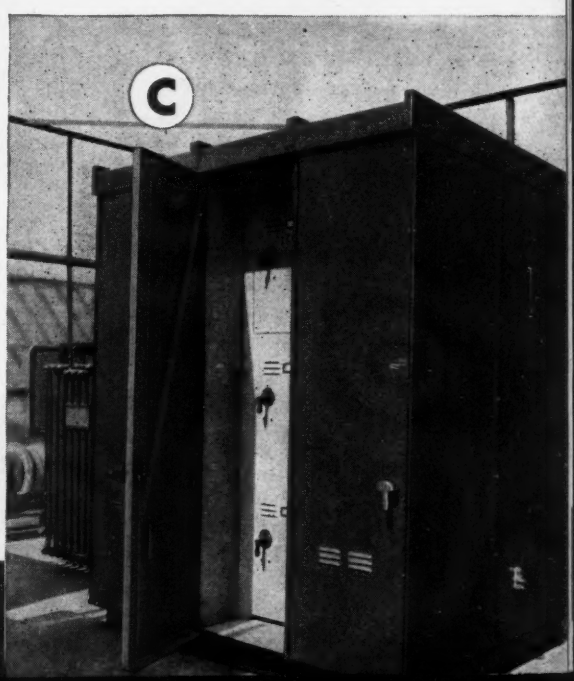




A METAL-CLAD SWITCHGEAR EQUIPMENTS—Our factory went right to work on these safety-enclosed, ***standard*** switchgear equipments, which protect and distribute primary power. Here they are shown installed—fully co-ordinated, metal-clad assemblies of breaker, instrument transformers, buses, and all associated equipment. They were received all ready to be set in place and connected.

B INDOOR LOAD-CENTER UNIT SUBSTATION—Load-center unit substations were put in to transform primary power at the load center, and distribute power at 480 volts right to the loads. These ***standard*** units are complete, combining Pyranol transformers, easily removable air breakers, current transformers, and buses, all co-ordinated as an integral part of the load-center unit substation.

C OUTDOOR LOAD-CENTER UNIT SUBSTATION—Here is one of the ***standard*** outdoor unit substations, installed. The unit substations, too, were received all ready to be set in place and connected.



Planning a New Plant, or Extension?

These three steps will help you to order standard switchgear equipments and unit substations for new war-production plants at an early stage of construction:

1 ***Calculate the total kva you will need.*** **Your consulting engineers can help you to determine this accurately.**

2 ***Divide the total load into separate load zones of 500, 750, or 1000 kva each.***

3 ***Divide the load of each zone into feeder loads*** **and draw a one-line diagram of your proposed load-center system, showing the functions to be performed and the ratings required.** ***With this one-line diagram you can immediately order your standard switchgear equipments and unit substations.***

For further aid, ask for our new bulletin GED-1006

GENERAL ELECTRIC

GETTING THE *MOST* FROM YOUR THERMAL INSULATIONS...

NUMBER 4 in a series of messages to American industry devoted to conserving heat, improving operation and increasing production through modern insulation practice.

PROPER APPLICATION IS IMPORTANT...

★ EHRET'S 85% MAGNESIA and many other Ehret heat insulating materials are fully treated, both as to selection and application, in the new 176-page Heat Insulation Handbook. It will be furnished, without obligation, to those interested in getting the most from their thermal insulations. Write today for your copy of Handbook B 208.

Canvas, paints and the ability of the painter are the raw materials which enter into the making of a painting. The degree of knowledge and skill possessed by the artist determines largely whether the finished picture will be a valueless daub or a priceless masterpiece. Similarly, even the best of thermal insulating materials will fail to fulfill their functions if they are not properly applied. Selection of an efficient time-tested material, such as Ehret's 85% Magnesia, is of primary importance. And the skill with which Ehret approved contractors apply coverings and blocks to piping, boilers and equipment is equally vital to overall insulating efficiency.

EHRET MAGNESIA MANUFACTURING CO.
VALLEY FORGE, PENNA.

...THERE IS AN *EHRET* DISTRIBUTOR OR CONTRACTOR IN EVERY INDUSTRIAL AREA

BULLETIN BOARD

WPB PRODUCTION DRIVE

STEP UP PLANT EFFICIENCY BY—

1 TAKING CARE OF TOOLS
2 PREVENTING BREAKDOWNS
3 CUTTING DOWN ACCIDENTS
4 GOOD LIGHTING
5 MAINTENANCE AND REPAIR
6 ADAPTING OLD MACHINES TO NEW USES
7 CUTTING WASTAGE
8 BREAKING PRODUCTION BOTTLENECKS
9 USING EVERY MACHINE TO THE FULLEST EXTENT

Five of the nine suggestions for "Increasing Plant Efficiency" in WPB's PRODUCTION DRIVE include problems in which Standard Lubrication Engineers can give you valuable help. For instance:

7 CUTTING WASTAGE

• CUTTING WASTAGE of oil is important. But cutting wastage caused by poor lubrication is one of today's most serious problems.

There's where a Standard Oil Engineer can be of real help to you. He can locate hidden waste that you might overlook in the press of other problems. Here are some of them:

- Excessive power consumption on conveyors, reduction gears, etc., caused by wrong lubricants.
- High labor costs for cleaning gear cases, oil circulating and hydraulic systems.
- Lost production time from unnecessary shutdowns for cleaning.
- Damaged equipment caused by the use of the wrong lubricant through inefficient lubricant handling methods.

There are many more ways that wastage can slow down your drive for production. Let a Standard Lubrication Engineer help you find them. Take advantage of his recent experience on problems just like yours.

HOW TO PREVENT WASTE IN HANDLING LUBRICANTS

The Engineering Bulletin, "Storage and Handling of Lubricants," may have a few timely suggestions for you to help prevent wastage caused by contamination of lubricants in your plant. It will be particularly helpful to new men in charge of lubrication. A copy will be sent you without obligation. Just write Standard Oil Company (Indiana), 910 S. Michigan Ave., Chicago, Illinois.

OIL IS AMMUNITION...USE IT WISELY

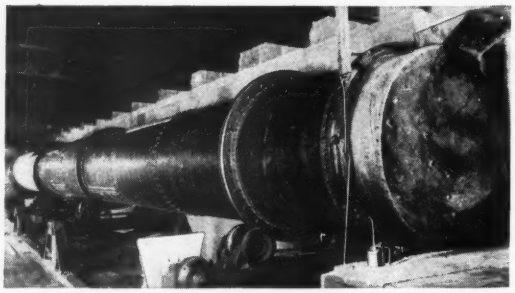
Copr. 1942, Standard Oil Company

STANDARD OIL COMPANY (INDIANA)

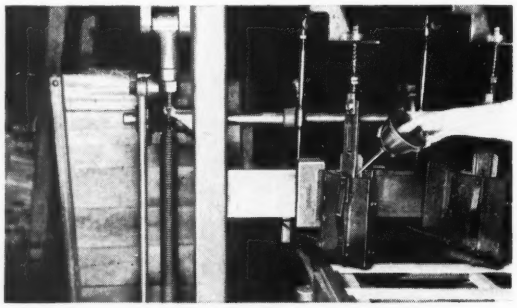
LUBRICATION ENGINEERING...LUBRICATION ENGINEERING...LUBRICATION ENGINEERING...LUBRICATION EN

STANODRIP CUTS WASTE AND WEAR ON ALL THESE MACHINES

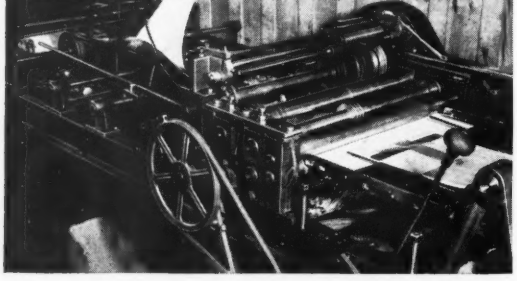
BEFORE redesigning or replacing leaky bearings, try Stanodrip on them. See if it doesn't eliminate the waste, damage to products, and dangerous oil spots around equipment as it did on the machines shown below.



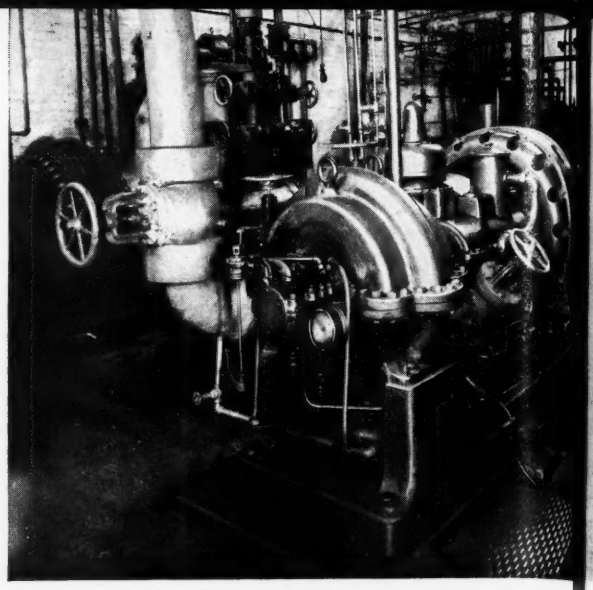
Bearings and slip ring on this toothpick polishing machine (above) screeched when lubricated with a straight mineral oil, unless they were flooded. But then oil leaked into the polishing drum and onto the floor. Stanodrip stayed off the floor, out of the drum, and in the bearings.



Sliding shoes on a stapling machine at a Wisconsin box company required a particularly tacky lubricant. A special product—difficult to get—was being used. Stanodrip was tested. With it, consumption was low, wear negligible, and it was easy to obtain.



The problem of stock spoilage on this paper folding machine was also solved with Stanodrip. It eliminated oil creeping along the shafts onto the paper. It reduced power consumption, too, because it stayed in the bearings, and kept them properly lubricated.



KEEP SMALL TURBINES ON THE LINE... LESS CLEANING ...FEWER OIL CHANGES WITH STANOIL

Every minute of generating capacity counts . . . every man-hour of labor is needed . . . every gallon of oil is vital. Cut wastage on all three. Put Stanoil on all turbine-driven auxiliary equipment. Here's an example of the saving you may make.

The turbo-generator, above, in a Michigan plant was shut down every six months to change oil and clean the oil system. Then, in July, 1937, Stanoil was installed. A recent letter from this manufacturer states, "You'll no doubt be pleased to learn that the Stanoil No. 25 which you recommended for our 250 KVA Turbine is still in use and apparently in good condition."

That means five years without a forced shutdown for changing oil . . . without the extra labor for cleaning, and with only a small amount of makeup oil used.

Ask a Standard Lubrication Engineer to tell you more about Stanoil and its application to gear cases, and circulating and hydraulic oil systems.

HERE'S WHERE YOU'LL FIND A STANDARD OIL ENGINEER

Call any local Standard Oil Company (Indiana) office in the middle western states listed below, or 910 South Michigan Avenue, Chicago, Illinois. In Nebraska, write Standard Oil Company of Nebraska at Omaha.

COLORADO • ILLINOIS • INDIANA • IOWA • KANSAS • MICHIGAN
MINNESOTA • MISSOURI • MONTANA • NORTH DAKOTA • WYOMING
SOUTH DAKOTA • WISCONSIN

OIL IS AMMUNITION . . . USE IT WISELY

STANDARD OIL COMPANY (INDIAN

...G...LUBRICATION ENGINEERING...LUBRICATION ENGINEERING...LUBRICATION ENGINEERING...LUBRICAT

Periodically, over 33 years, we have been asked this question. Uncle Sam asked it recently. The answers landed one of our largest government orders for Feed Water Regulators. Our own research staff is continually answering this question by experimenting with every known valve actuating force and with some not generally known. Over 60,000 users of COPES Thermostats answer the headline question this way.

1. The COPES Thermostat is simple, positive and rugged. It utilizes the expansion and contraction principle to develop a powerful mechanical force.

2. The COPES Thermostat responds quickly and evenly to load changes as reflected by changing water level. (5 to 8 times faster than an other common method.)

3. The COPES Thermostat is completely automatic, permanently accurate and dependable.

4. The COPES Thermostat will outlast the boiler it protects—requires nothing more than routine inspection.

5. COPES Thermostats are used outdoors on hundreds of boilers subject to the elements from —40°F. to +110° F. They can take it.

6. COPES Thermostats are made in several types to meet the space requirements of any installation on land or sea encountered in over 33 years of specialized Boiler Feed Water Control experience.

7. COPES Thermostats are proving these qualities in over 60,000 applications with boilers of all makes from 400 lbs. to 1,000,000 lbs. per hour capacity at all pressures up to 1900 lbs. under all kinds of load conditions in every part of the world.

For the benefit of new operating personnel in your power plant, write for text book titled, "Mechanical Feed Water Regulation for Boilers." For information about Flowmatic, the modern 2-element steam flow-control, write for booklet 409-B.

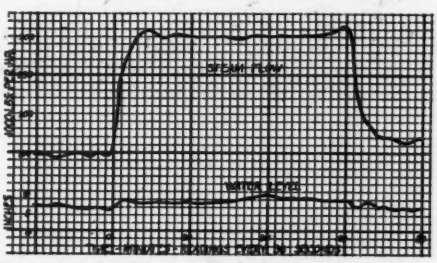
NORTHERN EQUIPMENT COMPANY

822 GROVE DRIVE, ERIE, PENNSYLVANIA

Feed Water Regulators, Pump Governors, Differential Valves
Liquid Level Controls, Reducing Valves and Desuperheaters

BRANCH PLANTS IN CANADA, ENGLAND REPRESENTATIVES EVERYWHERE

MORE THAN 60,000 COPES THERMOSTATS . . . Are Helping Make Charts Like This



The load charted on this central station boiler jumped from 150,000 to about 300,000 pounds per hour within 3½ minutes, the boiler water level rose only 2½ inches. This close stabilization of the water level was provided by a COPES Flowmatic Steam-Flow Type Regulator, adjusted to maintain a slightly higher level on heavy loads than on light. Flowmatic permits adjustments to provide any boiler water level characteristic desired.

COPES FEEDS BOILER ACCORDING TO STEAM FLOW-AUTOMATICALLY

★ GET CLOSER LEVEL CONTROL WITH THE FLOWMATIC ★ REGULATOR

You can simplify

use this check list

The turbine that has ALL these features, is the "most turbine for the money"

- **dual protection** against overspeed. Steam shut off simultaneously by *two* independently actuated valves.
- **spun blade tenons** to provide a permanent shroud fastening without setting up stresses in the blades.
- **sparkless overspeed trip** for explosive atmospheres.
- **contoured steam path** for maximum efficiency.
- **dynamically balanced rotor.**
- **iron alloy bushings** to seal the inlet valve stem—no soft packing.
- **steam strainer** around the inlet valve to reduce erosion and clean the steam.

You get *all* these features in a Westinghouse Type C turbine (*only* Westinghouse has them all) . . . and you get extra values, too. These extra values are important: specialized turbine engineering experience, covering the entire field from 5 hp to the largest; experience in designing and building condensers and steam auxiliaries . . . assurance of co-ordinated efficiency throughout the steam plant; a nation-wide field service that can put a steam expert in your plant on short notice.

[The nation's war needs may require certain changes in turbine materials. If such changes become necessary, you may be sure that the Westinghouse standards of quality will be fully maintained.]

J-50418

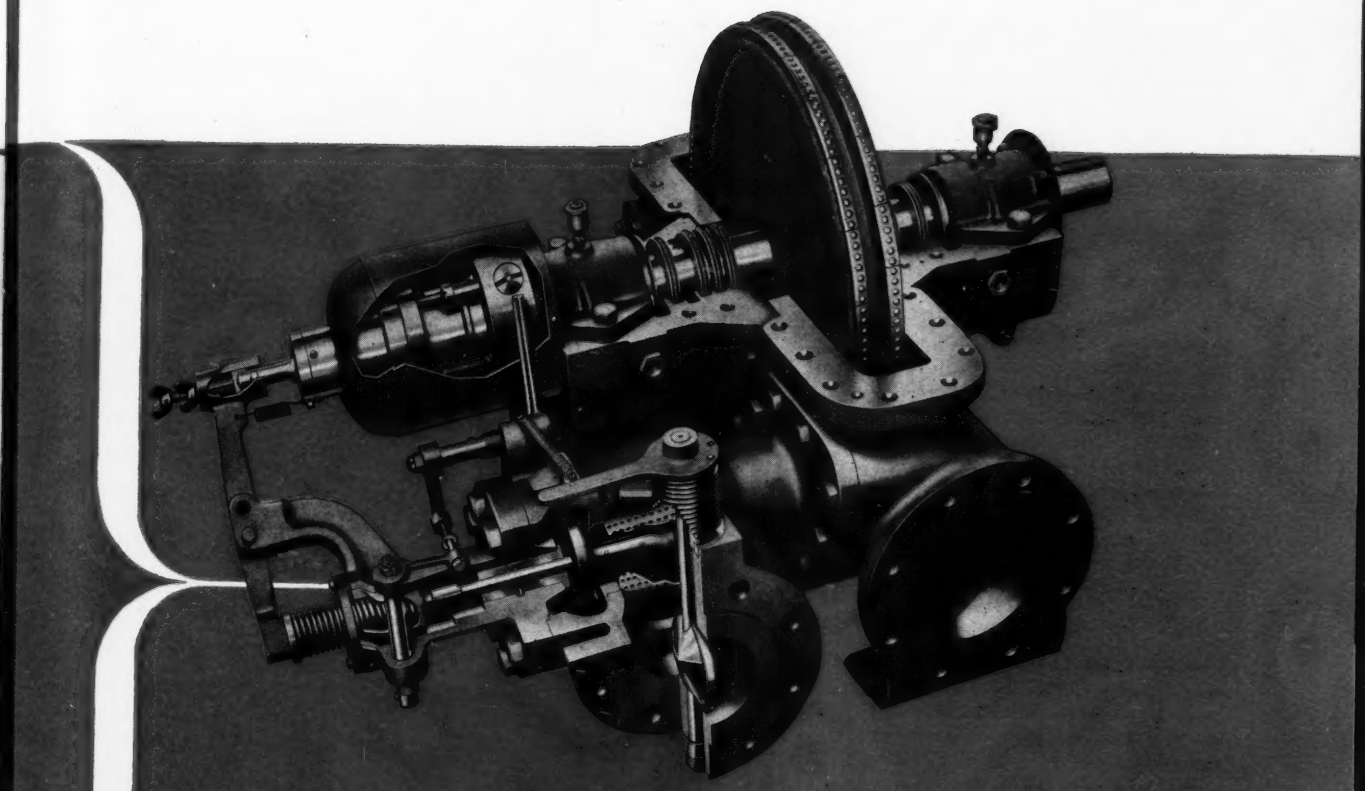
more help in the selection of your next turbines

These books give full application information: B-2230-A on Type C general-purpose turbines; B-3012 on Type CH heavy-duty turbines; F-8603-A on integral gear units; B-2278 on coupled reduction gears; B-2198-A on large industrial turbine generators. Write for the books you want. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N.

1 equipment—A *complete* range of steam turbines for mechanical or generator drive, from 5 hp to the largest . . . with a full line of auxiliary steam equipment.

2 engineering — A *complete* engineering service to help you select and apply the steam equipment best suited to your requirements.

y turbine selection



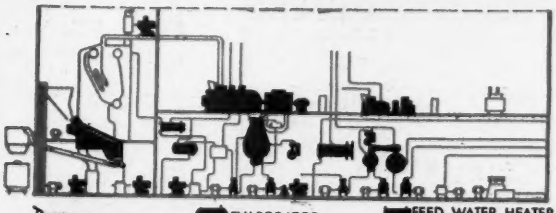
Standardized . . .

For quick, accurate assembly and easy maintenance

WESTINGHOUSE

Westinghouse

extra values in all these products of steam headquarters



TURBINE GENERATORS
STOKER
ASH EVACUATOR
EVAPORATOR
HEAT EXCHANGER
CONDENSER
VACUUM COOLING
FEED WATER HEATER
MECHANICAL-DRIVE TURBINE
CIRCULATING PUMP
CONDENSATE PUMP
AIR EJECTORS

AMERICAN *"Self-Cleaning" Hand Operated* STOKERS

The Timely Solution for the FUEL OIL SHORTAGE PROBLEM

THOUSANDS of users of types and grades of fuel threatened by impending shortages are now about to make decisions on the best kind of protection to install before the heating season starts. Many will favor changing over to hand operated grates as the solution offering the advantage of MINIMUM INVESTMENT.

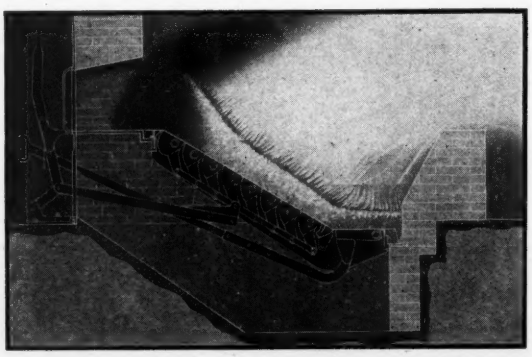
What may not be known is that this "minimum investment" will buy more than just ordinary grates. IT WILL BUY AMERICAN "SELF-CLEANING" HAND OPERATED STOKERS. Users report ability to maintain high CO_2 and carry loads as high as 150% to 200% of rated capacity with practically all kinds and sizes of bituminous coals. No electric or steam power is used. Power cost is zero.

There is no time to delay. Start now. Give us width and depth of furnace for quotation. We will be glad to help you make out proper applications for requesting a WPB rating to qualify for immediate delivery. *Write, wire or phone today!*

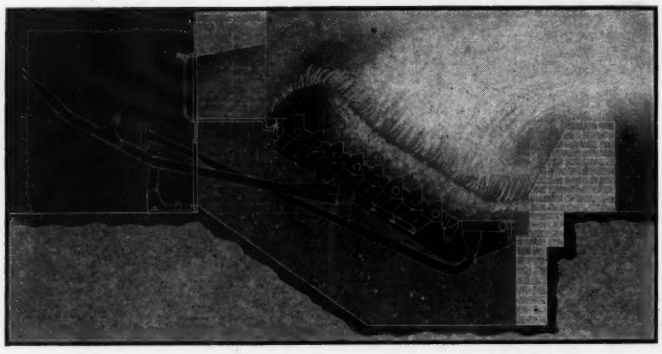
Opportunities for Sales Engineers
Some territories are open for experienced sales engineers familiar with steam plant boilers and furnaces. Information on request. Please furnish record of your experience and references.

FEEDING:

The coal is placed on the front of the stoker. Note the distillation of volatile gases from the green fuel at furnace front. The gas is completely consumed in passing over the hot coke in the rear.



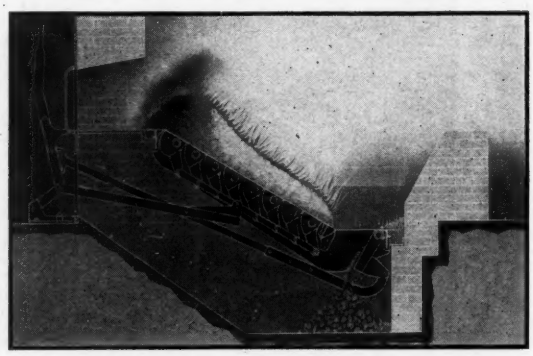
ONE LEVER DOES IT ALL!



An occasional pull on the lever advances the partially consumed coal towards the dump plate.

DUMPING:

Dropping the dump bar releases the dump plate and discharges ashes into the pit without disturbing the fire. Simple, effective, foolproof!



AMERICAN COAL BURNER COMPANY — FOUNDED 1918 — *Builders of Thousands of Overfeed Stokers*

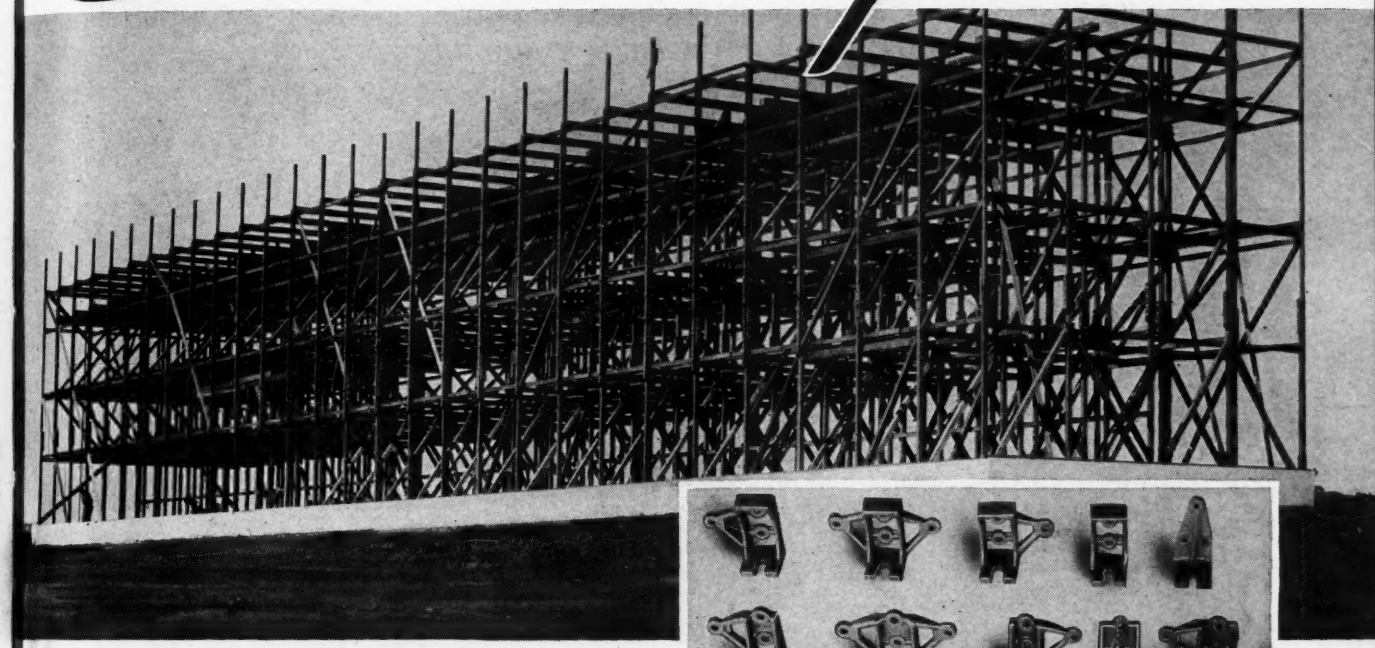
AMERICAN COAL BURNER CO., ENGINEERS
22-18 East Erie St., Chicago, Ill.
☐ Please mail descriptive literature.
☐ Send quotation on AMERICAN "SELF-CLEANING" HAND OPERATED STOKERS to fit the following furnace: Width..... Depth..... Kind of Boiler..... Size.....H.P.
☐ I am interested in selling AMERICAN HAND OPERATED STOKERS.
Name .....
Company .....
Address .....

QUICK FACTS:

1. **ANY SIZE.** Sizes suitable for firing any quantity of coal from 100 lbs. to 4,000 lbs. per hour.
2. **EASY TO ORDER.** Just tell us the dimensions of the furnace. See coupon.
3. **QUICK INSTALLATION.** Put it in in a day's time.
4. **MODERN FIRING METHOD.** Employs the fundamental "Cokal" firing principle—the coking method which government engineers, smoke departments, and combustion engineers all recognize as the highly successful method for burning coal smokelessly and economically.
5. **BURNS ANY COAL.** Uses local coals and cheapest grades of bituminous coal of all sizes from dust to mine run. No clinkers.
6. **EASY, SIMPLE OPERATION.** No expert handling of shovel required. Scorching, back-breaking cleaning periods eliminated.
7. **NO FANS, NO MOTORS—NATURAL DRAFT.** Power failure or enforced "black-outs" will not affect the operation of the American Hand Operated Stoker.

Another of MARLEY'S PLUS Features

One of a series of advertisements, each devoted to a Marley cooling tower feature that has become an accepted standard of the best practice in modern mechanical draft water cooling.

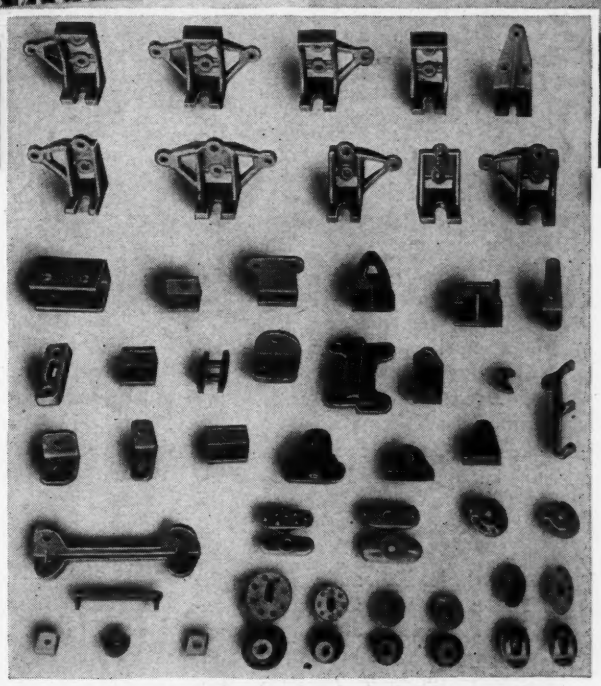


Structural strength is built into Marley Cooling Towers: (1) By proper and conservative engineering and design. (2) By using the recommendations of the *U. S. Forest Products Handbook* covering unit working stresses and other values. (3) By using materials and methods carefully determined as "best for service."

The large number of Marley towers produced, with the cumulative experience they represent, has enabled Marley engineers to establish *standardized details* for all sizes and types of towers to meet the various stresses that may be imposed or specified.

RUGGED FRAMEWORK — As the photograph above illustrates, diagonal bracing in both directions is liberally used in addition to the many columns and struts on close centers.

BOLTED THROUGHOUT — Strength of all connections is developed with bolts and plates, no nails being used. Only the framework is figured to carry the stresses, partitions and casing receiving no credit.

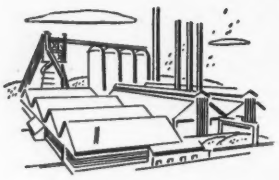


CAST IRON HARDWARE — Here pictured are a few items of Marley structural hardware used as column base plates, joint connectors, etc. "Side-hill washers" provide seats for bolting through diagonals without notching. Also various castings provide bearing surfaces for butt ends of diagonals.

These features which assure longer and safer years of service are but a few of the reasons why so many more cooling towers bear the Marley name.

MARLEY COOLING TOWERS

Every MARLEY TOWER *is individually engineered by* THE MARLEY CO., INC. — KANSAS CITY, KANSAS



Here's a *REAL* Yardstick for Control Performance!

...the Hagan job in the J&L Eliza works

THE five boilers in J&L's Eliza Furnace Department can produce a million and a half pounds of steam per hour. Automatically burning blast furnace gas, or any combination of gas and pulverized coal when gas fuel is scarce, they supply an unfailing steam supply for extremely fluctuating loads in the 96" strip mill. How they function is an engineer's dream.

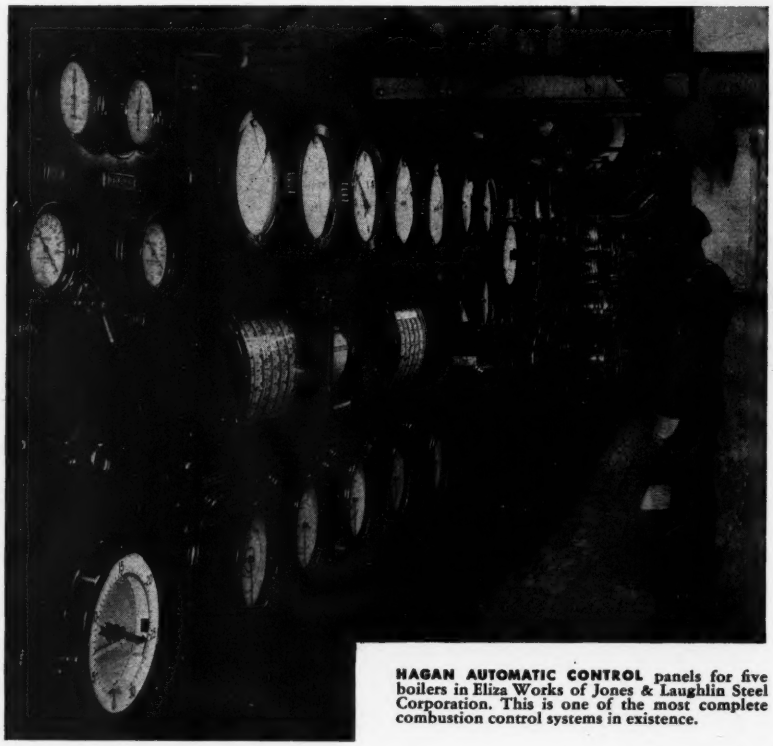
As each hot slab enters the rolls, the surging current, on the ammeter, nearly jolts the pen off the chart. In the load dispatcher's office, the recording wattmeter spins an uncanny story of instantaneous power load pick-ups of 20,000 to 25,000 kw.—and equally speedy cut-offs as the mills release their loads.

In the generating room, the turbine groans as it shoulders the violent load increases—and the steam-flow pen inks a wicked "sunburst" as it shifts with the load on a seesaw. But over near the boiler room the steam pressure chart shows maintenance of pressure at 410 lbs. *within one per cent!* Surely the boiler room gang must be working black magic to hold that pressure constant!

Along the firing aisle, on five gleaming panel boards, red and green lights flash on and off, silently signalling the *automatic* starting and stopping of powdered-coal burners, the opening and closing of dampers.

We pass one boiler and then another —not an operator is in sight. At the third boiler, one man calmly views the panel board while another man eats his lunch.

While the load is jumping all over the lot, Hagan Automatic Combustion Control is on the job, ably directing the complex system of fans, burners, dampers, boilers and turbines. Hagan Control maintains maximum fuel efficiency by correctly proportioning the fuel and air.



HAGAN AUTOMATIC CONTROL panels for five boilers in Eliza Works of Jones & Laughlin Steel Corporation. This is one of the most complete combustion control systems in existence.

It distributes the load evenly among the boilers, automatically regulates drafts and pressures *without human attention.* This is *fully automatic* Hagan Combustion Control at its best—the control system that thinks like an engineer and acts instantly!

WHAT CAN HAGAN DO FOR YOU?

Simply this. If standard Hagan equipment can handle the J & L-type loads—admittedly unusual—and maintain maximum efficiency *continuously,* that *same* standard Hagan equipment will do the best job you ever saw in your own plant —large or small—*without* pampering. All we ask is the chance to prove it.

HAGAN CONTROL JOBS IN J&L WORKS

Eliza . . . Combustion control for five boilers. Three pressure reducing and desuperheating systems. Full automatic control on slab-heating furnaces. Blast-furnace gas bleeder control.

South Side . . . Soaking pit control. Open-hearth furnace control.

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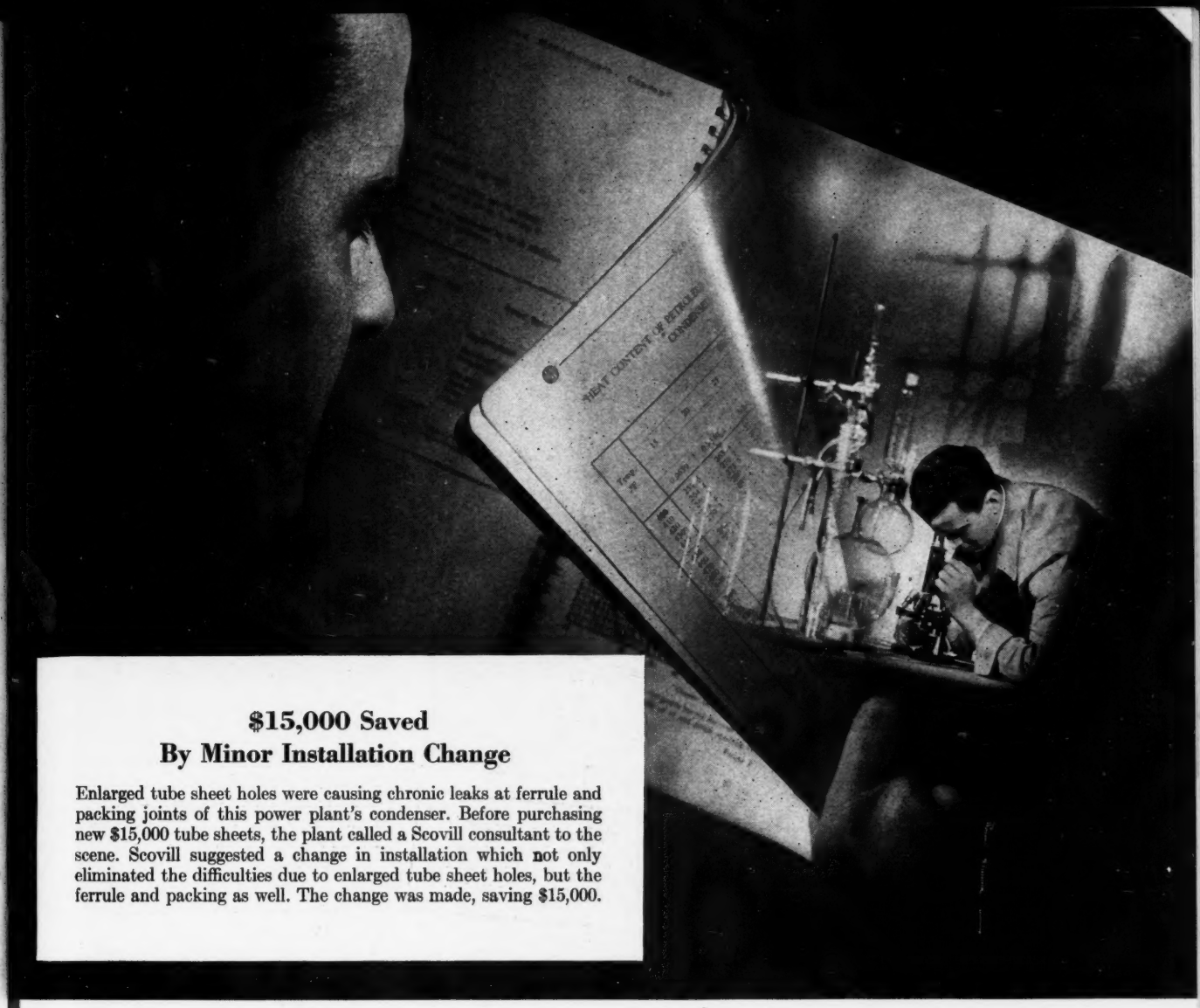

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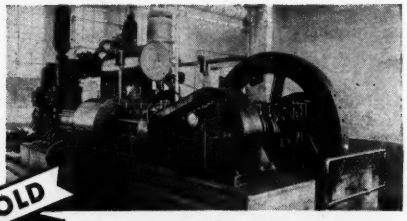

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POWER PLANT ENGINEERING

AUGUST, 1942

VOLUME 46, No. 8

Cover: A recent view of Grand Coulee Dam where a broad white avalanche of water will soon spill over the center crest—creating a waterfall twice as high as Niagara. The third, 108,000-kw. generator was placed in service recently, giving the development a capacity of 324,000-kw. During 1941 the power plant generated more than 200,000,000 kw-hr., enough power to produce aluminum for 500 four-motored bombers or 2800 fighter planes.

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PUBLISHED MONTHLY BY
TECHNICAL PUBLISHING CO.
53 W. JACKSON BLVD.
CHICAGO, ILLINOIS

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121 Waverly Road, Wyncote, Pa.

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SPECIAL REPRESENTATIVE
George E. Andrews

Subscription price $2.00 a year in the United States and Possessions. Other countries $3.50 a year. Single copy current issue 25c; back issue 40c.

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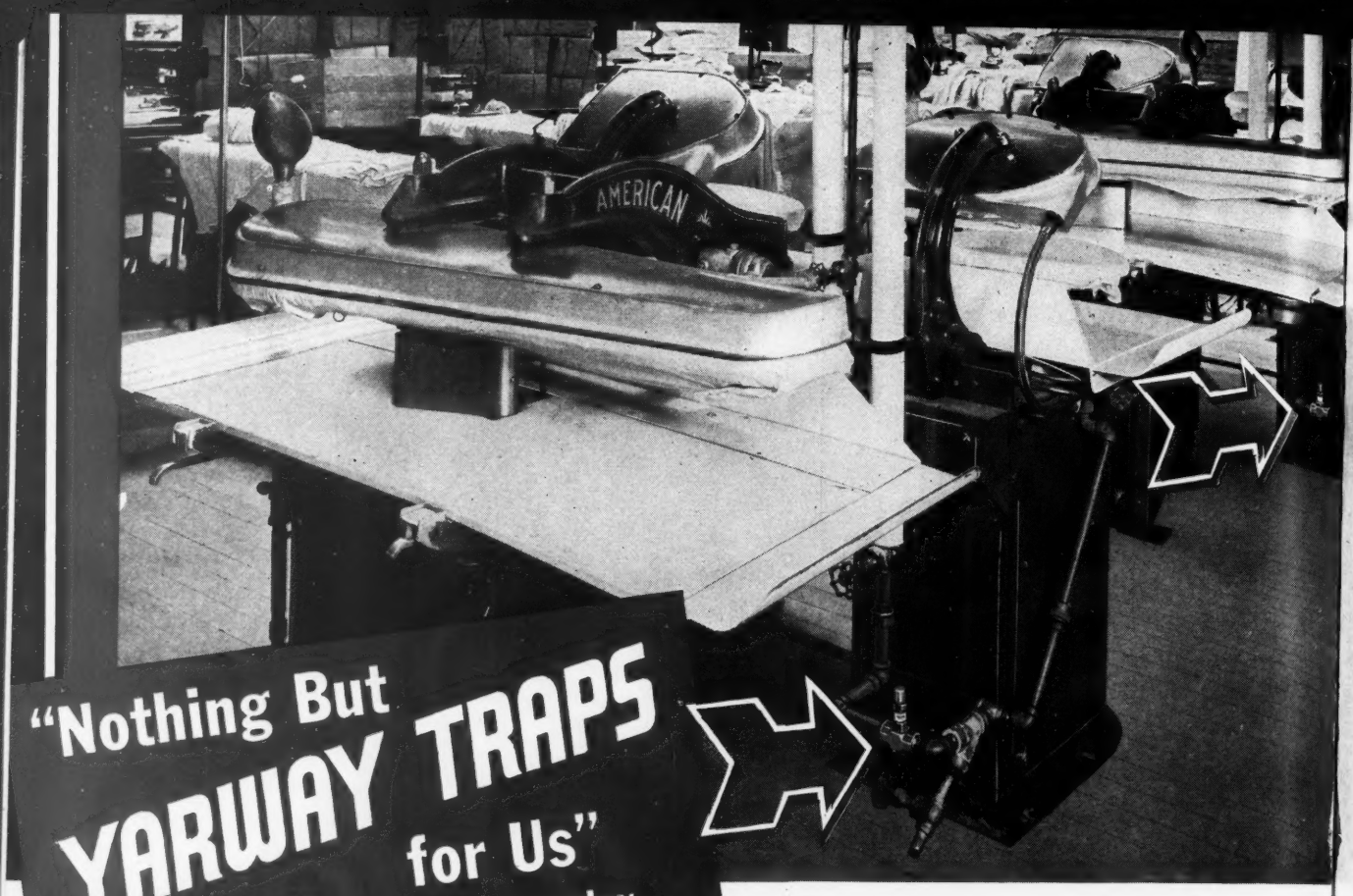

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WHAT LEADERS SAY

Inventions Lead to Victory

By COLONEL L. B. LENT

INVENTION, says the dictionary, is mental fabrication or concoction. By this definition, every fresh idea is an invention. Since human beings started to engage in mortal combat, those with the best weapons and smartest ideas usually emerged victorious. This has been true for thousands of years. In modern warfare, it is still true.

It is not too much to say that modern warfare is largely a battle of inventive ideas. In the past, American inventive genius has been largely responsible for the development of our industries and the constant betterment of our standard of living. When turned from peaceful pursuits to the problems of war, it will contribute powerfully, and perhaps decisively, to the success of the present efforts in the preservation of our kind of civilization.

In wartime, the number of inventions and suggestions submitted by the public for Governmental use increases to such an extent that some special agency is clearly needed, an agency whose only job is to give immediate and sympathetic attention to every invention, suggestion or idea which might have any possible value in our war plans. The National Inventors Council was created for that purpose. It has been in active operation since about October 1, 1940. Results to date show that it is of very real value to the military services and to others.

Its value, however, is in almost direct proportion to the number of contributions which come from the trained minds. During the first year of active operation of the Council, more than 40,000 cases have been examined by the staff.

The Patent Office makes no distinction between applications submitted to it direct and those previously presented to the Council. Submission of inventive ideas to the Council does not prejudice the inventor's interests, should he at any time desire to apply for a patent and all material submitted to the Council is held in strict confidence.

Inventions which have been found useful to one or more of the defense agencies can be classified roughly in two broad fields, namely: improvements in present devices or present methods; and ideas which are entirely new, but which may be so promising that military requirements and strategy can be planned to utilize them.

And it is also of interest to know that, of the ideas having potential value to the armed services—about 40 per cent are in the general field of ordnance, which includes all kinds of guns and ammunition and also tanks, amphibians, and fire-control devices; about 20 per cent are in the field of aircraft, including power plants and flying equipment and the remaining 40 per cent encompass all other phases of warfare. A relatively large number pertain to geometric and optical instruments and to radio and other electrical devices.

It should be encouraging to the prospective inventor to know that many, indeed most of our most useful items of military equipment have been devised and developed by civilians; in some cases by those who have had no experience in military affairs.

You may well ask, what kind of inventions do you want? It's not always easy to answer this question. If we were to tell in detail just what is wanted, it might disclose what we lack. And such information may be just as valuable to an enemy as knowing what we have; at least, so say the War and Navy Departments.

However, it's hardly necessary to say that any kind of inventions may be found useful in our scheme of national defense. One thinks first of those which have direct application in warfare. Such inventions are, of course, of prime importance and of much interest to the military authorities.

Entirely new conceptions may be found sufficiently potent as to justify a change in present strategy and tactics. But present military requirements must usually be met. Many inventions received by us have been found useful in expediting some part of our vast production program. In fact, the field in which useful defense inventions may lie is just about limitless.

And now we come finally to the question—How can the engineers help?

There are so many ways in which engineers can help that only a few may be mentioned. In the first place, keep in mind that inventive ideas which you may develop in connection to your own job may have some application to warfare. Next, give assistance to subordinates with inventive ideas and help them to organize their ideas and prepare their material for orderly consideration by others, also, discuss inventive ideas of your subordinates with them. A large percentage of inventions coming to us are found useless because the inventor is not familiar with the prior art nor is he well grounded in the fundamental physics or mechanics upon which his invention is based.

Some companies have a suggestion box into which employes may drop suggestions for more efficient plant operation. It might prove helpful if another question box be added, into which employes might put inventive ideas, which they think would be of assistance in our war efforts.

And finally, don't forget that some ideas, which may not be useful in connection with a particular device, may find a most useful application in some other field. Examples of this are numerous. One, very much in our minds at present, is that the same jet reaction which some have proposed for propelling rockets may find useful application as an added force in assisting airplane take-off from landing fields of small area or where runway facilities are inadequate.

COLONEL L. B. LENT, a graduate of Stevens Institute of Technology, Army officer, engineer, inventor, editor and trade association executive, is now chief engineer of the National Inventors Council, created by the Department of Commerce in August, 1940, specifically to receive, evaluate, and pass on to the armed service all inventions, ideas, new products and processes submitted by the public as a contribution to the war effort.

The Council, headed by Charles F. Kettering, embraces in its membership noted inventors, industrialists, public officials, Army and Navy representatives, and a staff of specialists headed by Col. Lent. Further details of the organization of, and specific need for certain types of inventions, can be found in Information Bulletin No. 2, How Inventors Can Help National Defense, obtainable from the Department of Commerce or from the Government Printing Office, the Superintendent of Documents at Washington, D. C.

$75,000,000 Worth of Ra

NOBODY ever saw $75,000,000 worth of radium all in one place. Indeed, nobody ever saw so much radium in different places because even at the prevailing price of $75,000 per gram, there is not that much worth of radium in the world. It would amount to 2.2 lb. or, as radium is usually measured, 1000 grams. You may wonder what all this has to do with the doughnut-shaped affair which the man in the photograph is holding in his hands; certainly, it does not look like it is made of radium and supposing it really was a rubber tire, they still are not worth that much—at least, not yet. Well, it is not a tire; it is what the inventor, Dr. Donald Kerst, whom you see holding it, calls a "Rheotron", a new type of vacuum tube developed at the University of Illinois and the General Electric Research Laboratory at Schenectady. It is capable of generating an electron stream and consequent gamma radiation equal in intensity to the gamma radiation in a corresponding beam from more than 1000 grams of radium. This, as mentioned above, is more than the world's existing supply. Although Dr. Kerst developed the theory of this device at the University of Illinois, last year he obtained leave of absence from the University to go to the General Electric Research Laboratory where he built the large unit shown above and described in greater detail on page 80

WITH THE EDITORS

◆ **INDUSTRY IS MEETING ITS CHALLENGE** . . . For the past 2 yr., industry has stepped into serious new problems at every turn of the road. First came the activities having to do with tooling up for the manufacture of war materials in quantity production. Then came the converting of many factories, which had heretofore produced nothing but peacetime products, into plants for the making of equipment or parts required for war machinery. Now with preliminary work fairly well in the background, every effort is being made to increase the output of war equipment plants to the limit of capacity.

Many of the problems confronted by managers and workmen in converted plants were new and strange. Materials used as well as sources of supply had to be studied and commercial machinery established in order that the flow into the plant would be coordinated with the needs of production capacity. In many cases the type of labor was entirely changed and factories were compelled to conduct training courses in order to develop qualified workers.

Inspection of parts, assembling and testing of units and shipping methods all had to be modified from previous practice. And the initiative for all these changed methods has had to come from industry with the Government doing little more than constantly demanding vast amounts of finished war materials. The demands are still being made, in fact greater and greater demands, but production is advancing so rapidly that manufacturing can no longer be considered the principal bottleneck in the production line. Government's major efforts are now being placed on securing materials sufficient to supply factories with their needs.

◆ **NEW METHODS** . . . Out of these new demands upon industry have come changes in design of equipment, methods of manufacture, and use of materials that will undoubtedly affect manufactured equipment in the years following the war. Laboratory research has indicated many desirable changes that could have been made years ago but for the inertia of individuals in control of industry. When factories, now totally engaged in war production are faced with the problem of reconverting to peacetime products, we may expect them to adopt entirely new methods with simplified designs and streamline production which will practically eliminate competitors who endeavor to carry on with prewar methods.

The scarcity of certain materials today is forcing designers of products not essential to the war effort to employ substitutes and many of these will be found to be more economical, and perhaps more satisfactory than materials formerly used. We may expect their continued use.

In the design of machinery, engineers are advocating the use of a lower factor of safety than has heretofore been considered practicable. This has come about through a better understanding of stresses, as revealed by studies with polarized light on models made of plastics, the use of welded joints subjected to X-ray inspection taking the place of riveted and bolted joints commonly used in construction of equipment, and the availability of materials that are more uniform and dependable than those formerly in use. Then too, with advancements made in metallurgy, engineers have a wider choice of material with which to fit exacting needs.

In the field of plastics, the list of materials is constantly growing and industry has scarcely begun to find uses for them all. Rubber, now almost forbidden to any but war industries, is being replaced in many of its most common uses by other plastics which, in many instances, offer such advantages over rubber that even if rubber becomes plentiful again the substitute material will be preferred.

Of particular interest to the power industry is the expansion of industries that depend upon electrolytic processes for the production of metals such as aluminum and magnesium.

◆ **RESEARCH CHANGING EMPHASIS** . . . War industries, because of the necessity for getting products into production rapidly, have been built largely upon industrial practices already common in factories. In some cases, however, these conditions have forced ideas and conclusions out of the fundamental research laboratories into industrial application where a different type of research must be carried on—the research leading to the perfection of application.

This change in emphasis was well expressed by L. A. Hawkins, Executive Director of the General Electric Laboratory, who recently stated that "Attainment of war objectives often forces research into wholly new fields, and provides new viewpoints of old fields. In normal times, it is the more fundamental researches which yield the more radically new developments. But such researches always, from their very nature, lack definite practical objectives, and often must extend over many years. Both characteristics tend to inhibit fundamental research in wartime. Today there are too many definite objectives calling urgently for immediate attainment to permit despersive pioneering, and quick results are worth infinitely more than results indefinitely postponed."

This change in the objectives of research has been taking place gradually over a period of years, but was greatly accelerated by the national defense and war programs. Last year out of 113 trade associations affiliated with the National Association of Manufacturers, 35 carried on research programs. At the National Bureau of Standards there are 74 research associates representing 25 associations and it has been reported that the volume of requests for the establishment of standards increased 50 per cent during 1941.

In a letter recently received from B. B. Williams, President of the Cooper-Bessemer Corp., statements are made which indicate that the change in type of research from the fundamental to the application took place in Germany prior to the start of the war. He writes of the development of synthetic oil and substitutes and the remarkable development of Diesel engines in that country for installation in tanks, trucks, tractors, trains and airplanes capable of using manufactured fuels. Quoting from Mr. Williams' letter:

"The development of synthetics and substitutes in the Axis countries is the factor which really upsets the calculations of those who believe that the answer to the entire problem (the breakdown of the Axis fuel supply) is merely a matter of adding up the total productions of the various oil fields under Nazi domination and then dividing the result by a figure representing the fuel consumption of the German military organization per day.

"By the beginning of 1939, a tax of 51 ct. per gal. had been imposed in Italy on gasoline and a 36 ct. tax in Germany. The reason? To encourage the development of synthetic and substitute fuels. There also were direct subsidies. At that time, about one quarter of all motor vehicle transportation in the Axis countries was accomplished with synthetic or substitute fuels.

"Gasoline made from coal gases was widely used. Alcohol made from vegetables was blended with straight gasoline. There were experiments with ammonia and acetylene. Some 25,000 vehicles in Europe used compressed gases as fuels. The German motorist, who had to pay 60 ct. per gal. for gasoline, could use city gas at a price equivalent to 43 ct. per gal. Forty-one cents worth of methane also took him as far as a gallon of gasoline. Propane-butane fuel was more expensive—equivalent to 61 ct. per gal.—but one tank full took the motorist some 225 mi."

Fundamental research has been responsible for the discovery of many new elements, materials, processes and reactions. The changed emphasis to the perfection of manufactured products, forced as it is upon industry, is undoubtedly laying the foundation for entirely new industries.

Herkimer, N.Y. Municipal

The installation of two new 1500-kw. turbo-generators at the Herkimer Municipal Lighting plant gives the system needed capacity for growing war production loads. The new generating units went into operation early this year under the existing steam pressure of 180 lb., but they are designed to operate at 400 lb. when contemplated high-pressure boilers are installed. The new installation also involves the conversion from 2-phase to 3-phase operation on the electrical system

THE NAME, HERKIMER, in this country is most usually associated with good dairy products—Herkimer County cheese has been famous for many years—but the Village of Herkimer is also important for other reasons. It is important for its manufacture of office furniture and its history is inextricably interwoven with Revolutionary doings and the early development of the Mohawk Valley. The Village was named after General Nicholas Herkimer, who was mortally wounded in the battle of Oriskany in August, 1777, but it was founded some 50 yr. earlier by Palatine Germans who bought a large tract of land from the Mohawk Indians and established settlements along the river on what was then known as the German Flats.

A thriving place in the early nineties, the village was early in its use of electricity for lighting. Only 8 yr. after Edison's Pearl Street Station started operation in New York the decision was made to install a street lighting system. It was on St. Valentine's Day, in February, 1890, that the Village Board passed a resolution to contract for an electric street lighting system and on June 30 of the same year the proposal of the Thompson-Huston Electric Co. to furnish this electric system was accepted. For some reason, however, this contract was never executed, but a few months later, in September, the General Electric Co. submitted a proposal to build an electric power plant at a total cost of $6600 and this proposal was accepted and executed. This contract called for a steam-electric generating plant together with 40 arc lamps.

This was the beginning of the present Herkimer Municipal Lighting System. If length of time of operation is any criterion by which the merits of an electric system can be measured, the Herkimer system should make a good showing since it has been in continuous operation for over 50 yr. The first plant consisting of a 100-hp., 80-lb. pressure boiler and an engine driven generator was inspected and accepted by the Board of Light and Water Commissioners on March 25, 1891. This plant supplied 50 arc lights, but in September, 1892, another contract was awarded for a second 50 lamp Edison Dynamo, at a cost of $1715.

This brief history furnishes a proper background against which to project the details of the present plant, a plant which recently has had its generating capacity augmented by the installation of two new 1500-kw. turbo-generators. Today, the system not only supplies current to the private homes and industries at rates which are extremely reasonable but furnishes to the village the current for various public uses such as street lighting, traffic signals, and public buildings. In fact, the electric energy furnished for these purposes figured at the regular rates amounts to approximately $13,000 annually plus maintenance of about $11,000, giving a total of about $24,000. Over the past 20 yr. of operation the net income from the operation of the electric system has averaged around $40,000 per yr. This income from the operation of the electric plant has helped to make up the deficits in the water department incurred by heavy interest payments on bonded indebtedness.

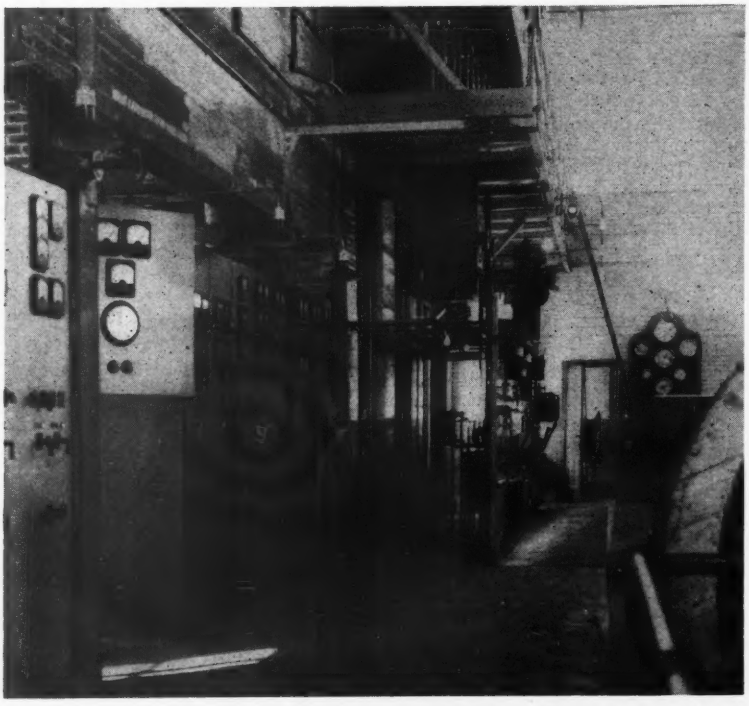


Fig. 1. A view in the turbine room showing the new switchboard with the old switchboard in the background

System Adds 3000 Kw.

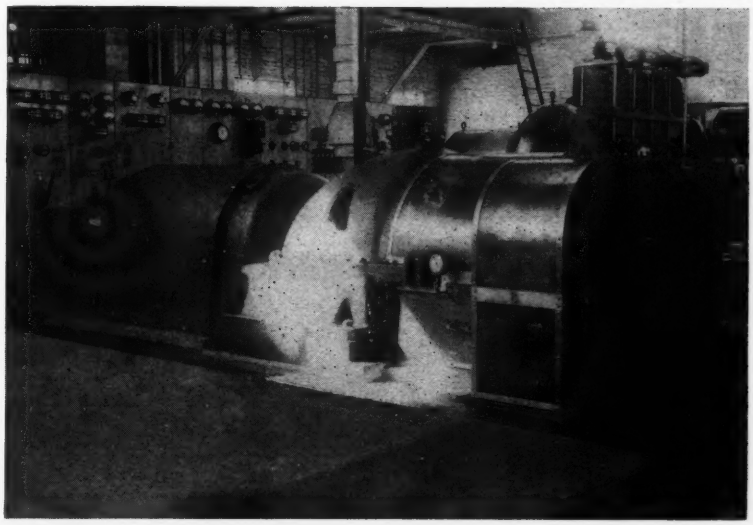


Fig. 2. One of the two new turbo-generators installed in the Herkimer plant

While these figures have little bearing upon the engineering aspects of the power plant, they do serve to indicate that the Herkimer plant is well managed and efficiently operated and that the recent increase in generating capacity is well justified on the basis of the plant's past record.

Until the new turbo-generators were installed early this year, the plant consisted of one 1000-kw. generating unit, one 500-kw. unit together with three 400-hp. 200-lb. pressure boilers and necessary auxiliaries. Both of these turbo-generators were Kerr turbines with Allis-Chalmers generators and both turbines exhausted into jet condensers. The boilers were fired by 4-retort steam driven Westinghouse stokers.

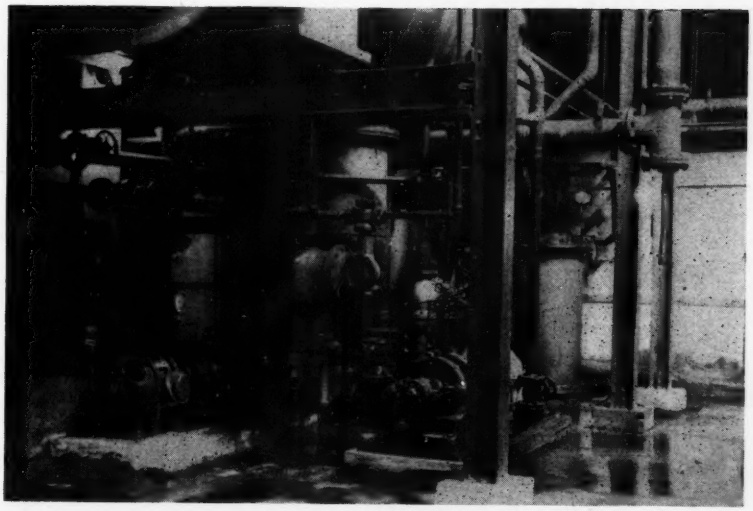


Fig. 3. On the condenser floor showing the condensate pumps

The generators were 2-phase machines operating at 2300 v. at which voltage the current was distributed throughout the village. During recent years the electrical load has been growing steadily and it became evident that it would soon be necessary to provide additional capacity. Plans in this direction were made several years ago and in 1940 it was decided, definitely, to proceed with the work. Gibbs and Hill, Inc., consulting engineers of New York, were retained to design the new installation.

Since both of the existing generating units were old and rapidly approaching the time when they would become obsolete, it appeared expedient to add sufficient new capacity not only to supply the increasing load but to retire most of the existing capacity from service as well. Accordingly, it was decided to install two new 1500-kw. generating units together with the necessary auxiliaries. These two units would provide ample capacity to carry the growing load and the two old units would still be retained as standby equipment for use in emergencies. Certain modifications in the building structure were necessary to accommodate the new machines so when these modifications were made provision was made for installing a possible third new unit in the future.

The existing generators as indicated above were 2-phase machines. While the distribution system in Herkimer is a 2-phase system, in considering its future development it was felt that the new generators should be 3-phase units to conform with more general practice and to provide for a change to a 3-phase system. The new generating units, therefore, are 3-phase machines and a 2000-kv-a. Scott connected transformer was provided to serve as a link between the 3- and the 2-phase systems. This transformer is installed outside the building adjacent to the station transformers.

The general arrangement of the plant is shown in Fig. 4. This shows the relation of the two new generators with respect to the old ones and also shows the location of the boiler room. Except for new piping, a new feedwater heater and a new feedwater pump,

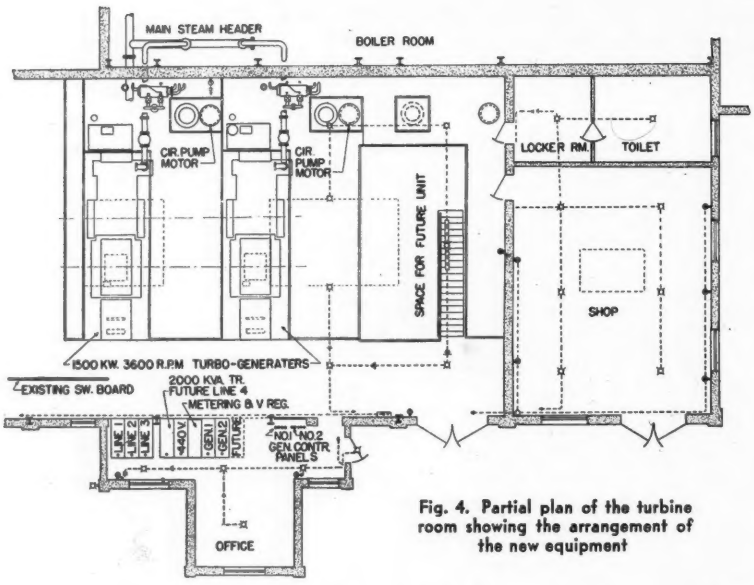


Fig. 4. Partial plan of the turbine room showing the arrangement of the new equipment

no changes were made in the boiler room. For the present, the existing boilers will continue to serve the plant. The new turbo-generators, although built for 400 lb. pressure, are being operated at 180 lb. which is about all that the existing boilers can safely stand. Ultimately, these old boilers are to be replaced by new high-pressure units which will permit the new turbines to be operated at their design pressure.

In the turbine room, the installation of the new generating units also made necessary the installation of a new switchboard. The old switchboard still occupies one end of the room and still is used to control the current generated by the old generators, but for the new generators a new steel enclosed type of board is provided. The comparison between this new board and the old one is indicative of the advance in switchboard design in the last two decades. The old board, no doubt, was the last word in design when it was installed. It is of marble, provided with oil circuit breakers and mounted away from the wall by means of tie rods. The new board, on the other hand, is smooth, sleek and streamlined with semi-flush instruments, electrically controlled switches and circuit breakers and finished in a light satin finish.

Turbo-Generators

The two new turbo-generators are Elliott Co. units, each exhausting into a Westinghouse surface condenser below. The turbines as already mentioned are built to operate at 400 lb. steam pressure and drive the generators at a speed of 3600 r.p.m. The generators are rated at 1500 kw. or 1875 kv-a. 80 per cent power factor and generate 3-phase 60 cycle current at 4150 v. This voltage, it will be noted, is higher than that of the old generators. Each unit is provided with its own direct-connected exciter.

The surface condensers are of the welded steel shell type of construction equipped with Westinghouse C-21 air ejectors operating at 150 lb. pressure and provided with 58 sq. ft. inter and after condensers. Circulating water for the condensers is provided by motor-driven submerged, vertical, Byron Jackson pumps. This circulating water is drawn from a power canal which serves some of the industrial water power plants in Herkimer.

This canal is located slightly over 1600 ft. away from the power plant. The water is withdrawn from the canal and delivered to the power plant through a 30 in. cast iron water pipe laid on a .0025 grade buried some 8 ft. below the surface of the ground at the intake and 18 ft. at the station. A screen house is provided at the intake where provision is made for thawing ice formation that might accumulate on the screens in winter.

After passing through the condensers the water discharges through a 24 in. pipe into West Canada Creek some 300 ft. from the plant in the opposite direction from the canal. In addition to the suction line from the canal there is also a suction line from West Canada Creek. The intake of this line, which is also a 30 in. line, is located 35 ft. upstream from the discharge. The pipe is laid on a level grade from the plant to the creek.

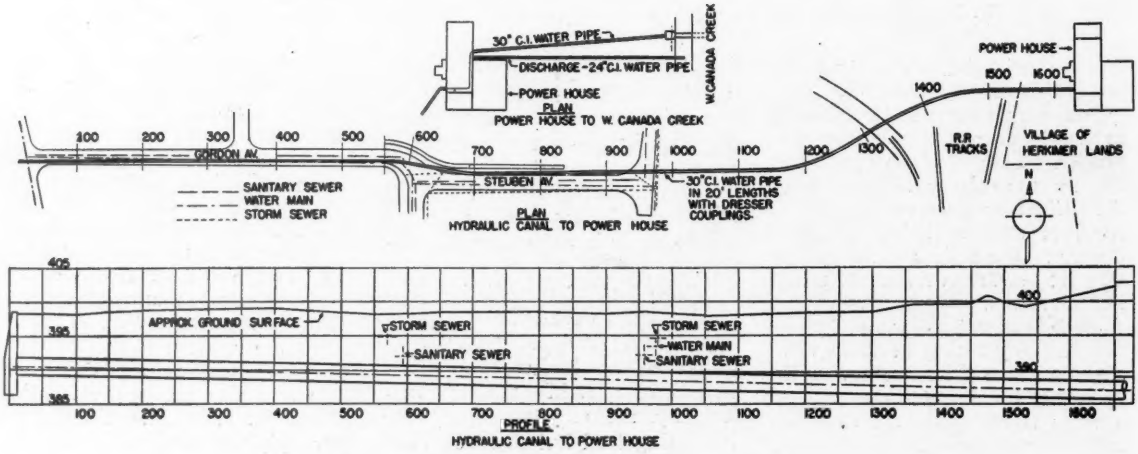


Fig. 5. Profile and details of the circulating water pipeline

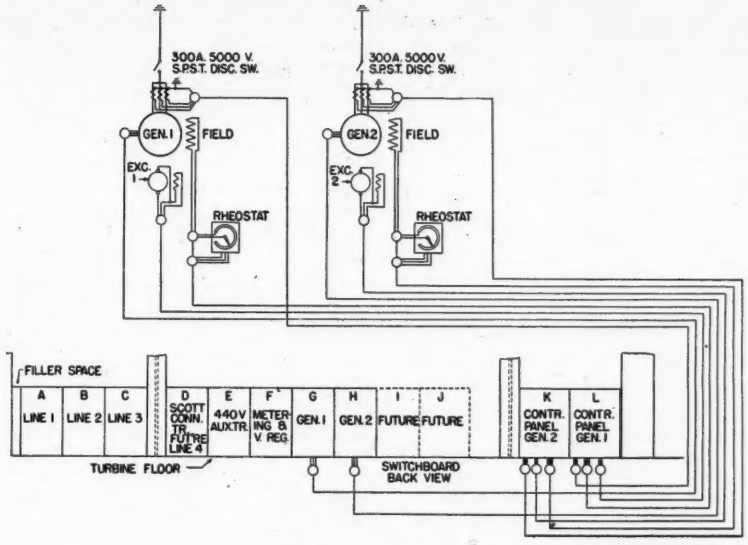


Fig. 6. Simplified wiring diagram

An unusual feature of the circulating water system is made possible by a positive head of 7 ft. on the canal supply over the creek supply. To clean the 30 in. line it is only necessary to open both 30 in. valves in the plant during regular operation, allowing the water to pass through to the creek carrying all accumulations of mud, sand, etc., with it into the intake wells at the creek where it may be cleaned out while the canal water is being used to operate the plant.

In addition to these two sources of condenser circulating water, provision is also made to supply city water in case of necessity. The arrangement for accomplishing this is of interest in that certain sanitary ordinances do not permit a physical connection between the city water system and the creek water system. To circumvent this restriction and at the same time comply with the law an interesting arrangement is used. A standpipe of comparatively large diameter rises from the main circulation suction line in the basement. The upper end of this standpipe is open and into it a gooseneck from the city water line is inserted. The standpipe is made tall enough so that the level of the water in the circulating system can never rise up to the gooseneck. Thus city water can be discharged into the circulating system, but water from the circulating system cannot flow into the city water line. Even if the circulating water rose to the top of the standpipe it would only overflow, but there would be no danger of contamination. While it is unlikely that city water will be needed for circulating purposes this arrangement does make available an emergency supply.

The boiler feedwater is taken from the city supply. Until the new turbines were installed the water was treated by means of a Cochrane hot process softener, but since the new generating units and the new feedwater heater was installed this method of treatment has been discontinued and replaced by chemicals mixed in the chemical tank of the Cochrane system and pumped directly into the suction line of the feed pumps at stated intervals. Tests are made for hardness, and the concentration of the water in the boilers is controlled by a continuous blowdown system.

Steam for feedwater heating is supplied by a steam turbine driving the forced draft fan and by a steam turbine driving a feedwater pump. This is supplemented as necessary by steam extracted from the new turbines. At present the steam pressure carried on the heater is only 5 lb. but it is planned to boost this to around 10 lb. in the near future. The new heater is a Cochrane deaerating heater fitted with float level con-

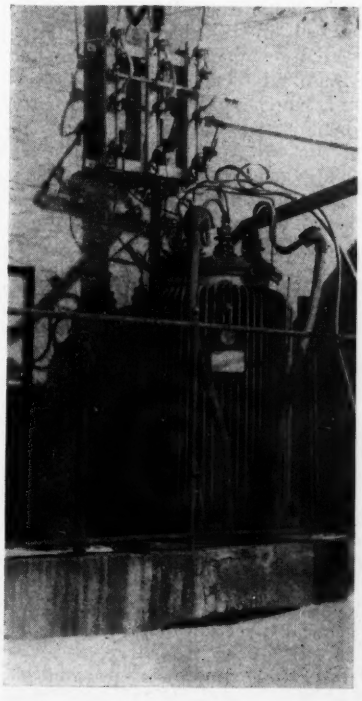


Fig. 7. (Left) The Scott-connected transformer which interconnects the 2 and 3-phase systems

Fig. 8. (Below) Another view of the new turbo-generators

PRINCIPAL EQUIPMENT IN HERKIMER MUNICIPAL POWER PLANT

GENERAL

Location: Herkimer, N. Y.
Type of Plant: Steam-electric.
Service: Municipal light and power.

NEW EQUIPMENT

2 Elliott Co. turbo-generators, each consisting of a 1500 kw., 1875 kv-a. 80 per cent power factor, 3-phase, 60 cycle, 3600 r.p.m. generator direct connected to a 450-lb. press. turbine, and with direct-connected 20-kw. exciter.

2 Westinghouse Electric & Mfg. Co. surface condensers of the welded steel shell type construction.

2 Westinghouse Electric & Mfg. Co. Size C-21 air ejectors, 150-lb. press. each with 58 sq. ft. inter and after condensers.

4 Westinghouse Electric & Mfg. Co. centrifugal condensate pumps, two driven by 10-hp. 175-lb. press. steam turbines, the other two by 10-hp. 220-440 v. motors.

2 Byron Jackson Co. vertical submerged type circulating pumps driven by 25-hp. 220-440 v. 880 r.p.m. General Electric Co. induction motors.

2 Schutte & Koerting Co. generator air coolers.

1 Yeomans Bros. Co. sump pump driven by 5-hp. Howell Electric Motor Co. 220-440 v. induction motor.

1 Ingersoll-Rand boiler feed pump driven by General Electric Co. motor.

1 Cochrane Corp. deaerating feedwater heater fitted with float level control and high and low level alarms.

1 New 10 panel General Electric Co. switchboard together with swinging panel for synchroscope, a.c. voltmeters and frequency meter. With the exception of the two generator control panels all panels are of the steel cell type construction. All relays and instruments of semi-flush design. Generator voltage regulators, General Electric Diactor type.

MISCELLANEOUS NEW EQUIPMENT

Motor Controls, General Electric, Westinghouse, Cutler-Hammer, Square D.
Lightning Arrestors, G. E. Thyrite.
Storage Battery, 60 cell Exide, Electric Storage Battery Co.
Storage Battery Charger, Raytheon "Recticharger."
High Pressure Valves, Walworth Co., Inc.
Steam Pressure Regulators, Swartwout Co.
Vibration Tachometer, James G. Biddle Co.

OLD EQUIPMENT

1 1000-kw. Kerr, Allis-Chalmers turbo-generator, 3600 r.p.m., 2-phase 60 cycle, with 1200 r.p.m. exciter driven through Poole gear.

1 500-kw. Kerr, Allis-Chalmers turbo-generator, 3600 r.p.m., 2-phase 60 cycle, 2300 v.

1 15-kw. General Electric motor generator set.
Manistee jet condenser on 500-kw. turbine.
Westinghouse jet condenser on 1000-kw. turbine.

3 400 hp. Babcock & Wilcox boilers, 200 lb. 100 deg. superheat.

3 4-retort Westinghouse underfeed stokers.

1 Gould boiler feed pump.

1 Manistee boiler feed pump.

2 Buffalo forge fans.

1 Booster feedwater pump.
Cochrane continuous blowdown equipment with feedwater heater and hot process softener.
Gifford-Wood coal unloader, elevator and conveyor.
Jeffrey coal crusher.

3 Richardson automatic coal scales.
Bunker capacity, 45 ton per boiler.
Copes feedwater regulators.
Bailey feedwater meters.
American steam jet ash conveyor.
Cash automatic draft, damper and coal feed regulators.

trols and with high and low level alarms.

Condensate is removed from each of the main condensers by means of either of two condensate pumps. Both of these are Westinghouse centrifugal units, but one is motor driven while the other is turbine driven.

All new steam piping installed in connection with the new turbo-generators is of steel welded construction and all designed for use at 450 lb. pressure. A new horizontal main steam header was installed in the boiler room and from this header two leads take off to the two turbines. The header is provided with two extra flanges, one to serve a future turbine and the other to connect to a future high-pressure boiler. The turbine headers are located below the floor.

Fig. 9. An outdoor view of the plant in winter

The station is well equipped with instruments. In addition to the electrical instruments on the main switchboards each turbine is provided with a gage board containing steam pressure gages for indicating throttle pressure, steam ring pressure and extraction steam pressure. Vacuum gages and a barometer are also provided. The speed of the turbo-generators is indicated by James Biddle vibration tachometers.

The new switchboard, already referred to, is a General Electric Co. board of the most modern design. It consists of two sections, one of two panels with space for a third, for the control of the two new generators and another section of eight panels for the relays and watthour meters for the generators and the feeders to different load centers of the distribution system. The main generator oil circuit breakers are mounted in cubicals which constitute the relay panels. This entire second section is of the cubical type of construction with the buses enclosed. The main generator field rheostats are located in the basement on the condenser floor and are remote controlled from the generator control panels. The location of the switchboard and the arrangement of the panels is shown in the accompanying layout of the station. A 60-cell Exide storage battery is installed together with a Raytheon Recticharger for furnishing direct current for the control circuits.

From this brief description, it will be evident that the Village of Herkimer is well fortified to meet any power situation that may be expected to prevail in the near future. Fortunately, the Municipal Commission and the Engineering Department had the foresight to anticipate the expected demands and to act when it was still possible to get equipment. Had they waited a year longer, this expansion could not have been made.

The plant is operated under the general direction of H. W. Bachelder, Engineer in Charge, who also supervised the new installation.

Modern Distribution Fuse Links

Despite its simple structure and its seemingly simple principle of operation, the fuse link must be carefully designed. It does the job of an overcurrent relay in protecting equipment and in maintaining continuity of service and, as such, it must have an accuracy approaching that of the relay. In this article the author discusses the important requirements and characteristics of distribution fuse links to bring about a better understanding of their performance

By G. F. Lincks

Distribution Fuse Cutout Section, General Electric Co., Pittsfield, Massachusetts

THE FUSE LINK is the heart of any fuse cutout and thus its ability to meet service requirements is the governing factor in the successful operation of the combined devices. No other similarly priced electrical apparatus except the electric lamp requires as much engineering attention in design and manufacture as the modern distribution fuse link. In order to secure the greatest return from the investment in distribution fuse cutouts, it is important to know the service requisites of such a fuse link. They are of equal importance.

Service Requisites of a Modern Fuse Link

1. The fuse link must aid in clearing low fault currents without detracting from the high interrupting ability of the fuse cutout. The majority of faults on distribution systems involve comparatively low currents, the clearing of which presents a major design problem in all fuse cutouts. This is especially true with indicating and dropout cutouts because the circuit must be cleared before the main contacts of the cutout separate or an arcover may occur. (See Fig. 1.)

2. The fuse link must aid and not deter the quick pulling apart of the burned ends after it melts even when there is no expulsion action under low fault conditions. Otherwise there can be no indication or no dropout action to remove the fuseholder from the circuit. Generally, any failure to pull apart the burned ends of the link results in a burned up fuseholder and occasionally a destroyed cutout. The tension to cause this action is comparatively small as indicated by the NEMA standard that fuse links must withstand a 10-lb. pull when cold. The ability to pull apart is influenced by oxidation in service due to the stiffening of the flexible cable of the fuse links.

3. The fuse links as manufactured over a wide period of time must meet the published time-current characteristics with a high degree of dependability and accuracy which at least approaches that of the induction type relay. This high standard is entirely within the realm of economical design and manufacture.

Every individual part of the fuse link from the button head cap to the tip end of the flexible cable contributes to the correct operating function of the cutout. Each part demands equal engineer-

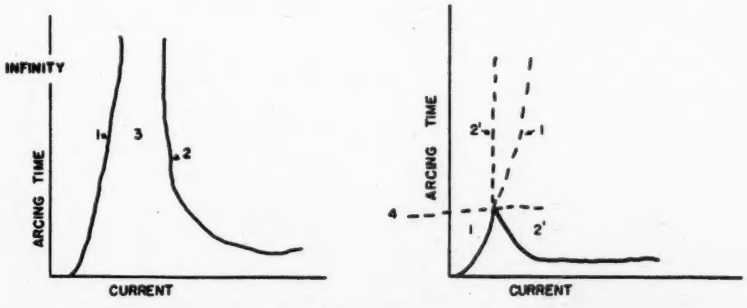


Fig. 1. Explanation of how auxiliary tube aids in the successful low current operation and why the cutout in which the contacts separate after fuse melts impose extra requirements (b) (3) on the fuse links and thus require attention to the provision of the proper bore and length of the auxiliary tube

(a) Operation in fuseholder without auxiliary tube.

(1) Fuse interrupts low currents by melting away fuse wire and/or mechanical separation.

(2) Pressures high enough in fuseholder to cause expulsion action which quickly decreases arcing time.

(3) Dead zone where circuit is not cleared.

(b) Operation with auxiliary tube on fuse link in fuseholder.

(1) Fuse interrupts low currents by melting away fuse wire and/or mechanical separation.

(2') Pressures high enough in auxiliary tube on fuse link to cause expulsion action.

(4) Maximum arcing time—must not be exceeded, otherwise arc will be drawn between contacts of indicating or dropout cutouts when they separate after fuse melts.

ing attention both in design and in manufacturing under conditions of mass production. This attention to detail must be carried so far that it shows up in the actual appearance of the fuse link. Of course, the attention to technical details in the design will not be descernible visually.

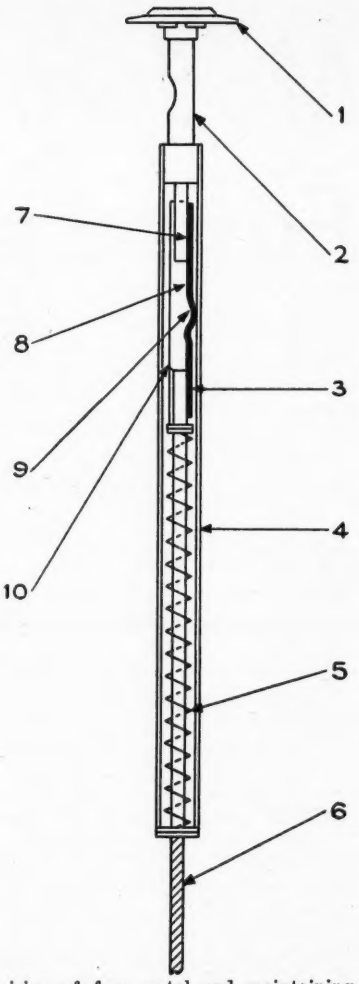
The requisites of some of the major parts of the fuse links are reviewed in Fig. 2. This illustrates the function of each individual part in helping the fuse cutout to carry the load and then after clearing the circuit of excessive currents to require merely the replacement of the fuse link to restore it to an operable condition. Any other kind of operation may require extra labor or a longer outage. A line crew may have to cut down the old cutout and put up a new one.

Accuracy Approaching a Relay

Fuse links are doing the job of an overcurrent protective relay in protecting equipment and continuity of service out on the line where they provide an accuracy approaching that of the relay. Such accuracy requires the attention accorded an instrument in designing, manufacturing and packing for protection until installed. Let us consider the major factors involved.

The high-current end of the melting time characteristic curve is a mathematically predictable characteristic, dependent entirely upon the cross section and material of the fusible wire. It is a hyperbolic function (I^2Rt) and thus when plotted on log-log paper decreases two units in time per one unit increase in current, a 2 to 1 slope. This condition persists as the current decreases until the time is sufficient to permit the radiation and conduction of heat from the fusible section to have an appreciable effect. Then the low current end of the time-current curve is bent upward, so that it approaches the vertical line. The degree of this bending is dependent upon the length of the reduced section. Of course, it is affected also by the ability of the adjacent parts of the fuse link to absorb and conduct heat away from the fusible section. Once the conditions have been established so that the time-current characteristics of a fuse link meet the requirements for coordination with motor starting demand currents and relay characteristics, it is necessary to hold all possible variations within extremely close limits. Any variations in the purity of metal, melting temperature, cross section and resistivity of the fusible section will change the characteristics in the high-current end. Differences in the length of the fusible section affect the accuracy of the low-current end of the curve sufficiently so that the length must be held within limits of a few thousandths of an inch.

Fig. 2. Analysis of function of some of the individual members of fuse links. Each member must do its part correctly for dependable overall operation of cutout



(Figures in explanation below correspond with figures above.)

1. The button head cap must function as a gasket when clamped down against the top of the fuseholder to keep the hot conducting gases and molten metal out of the threads. Otherwise a Stilson wrench may be required for re-fusing. Tests and service experience have shown that the pressure will "Gas cut" through any thin edge.
2. The shank between the button head cap and the fusible section must be short, in order to prevent excessive temperatures at the fusible section causing deterioration of the fibre fuse tube without raising the temperature of the fuse-holder terminal above allowable limits.
3. The terminal must be solid to prevent mushrooming the end of the cable by the explosive pressure and should have no sharp edges.
4. Auxiliary tubes on the fuse links make possible the quick clearing of low fault currents. When properly designed they provide the speed necessary for arc interruption in the tube before the separation of the contacts of indicating and dropout cutouts. See Fig. 2. Of course, the cutouts must provide this time delay before the separation of the contacts.
5. The spring must cause wide separation of burned ends of link at low-minimum melting-currents of small size links especially in non-indicating or non-drop-out cutouts.
6. The cable extension at the lower end of the fuse link, even after being oxidized in service, must be sufficiently flexible to permit indicating and dropout cutouts to pull the burned end of the fuse link apart even when there is no expulsion action. Balanced against this ultra flexibility is the need for low I^2R losses to reduce the heating of the fusible section and cutout. Low losses are necessary in order to keep to a minimum the difference in time-current characteristics, resulting from their use in both long and short fuseholders.
7. Joints at fusible section—The joints should be so fastened that progressive heating and cooling will not cause deterioration.
8. The fusible section should be designed so that it will carry all loads and melt at all currents without carbonizing the auxiliary tube or the fuseholder before the fuse link melts. When such precarbonizing occurs at low currents, it causes arcing to continue across the carbonized path which destroys the fuseholder and possibly the cutout.
9. High accuracy demands close supervision of fuse metal and maintaining the length within very small limits.
10. Strain wire should stand 10-lb. pull under continuous full-rated load. (NEMA calls for 10-lb. cold.) Tests indicate that the strength of this wire will not reduce with age. Excessive strengths may mean damaged fuse links when melting currents persist only 50 to 80 percent of the time required to cause melting. (Especially with small sizes.) The initial strain should be on strain wire, not on fusible element.

Little details such as sharp edges, too close fits, auxiliary tubes which warp, or anything else which prevents the free movement of the fuse link out of the fuseholder may jeopardize the total investment in the fuse cutouts in which such fuse links are installed.

In the manufacture and application of any product, there are variations commonly lumped under the heading, "human element". In fuse link manufacture, error-proof tools and fixtures are imperative and poor workmanship cannot be countenanced. Despite this, there will be human errors such as the use of stretched or improper fusible sections, defective soldering or crimping, incorrect

stamping of the rating on the button head cap, and so forth. Careful inspection and checking of the product against a standard resistance has been proven exceedingly effective in eliminating these variables.

Laboratory tests at the factory and by utilities have shown that fuse links from one carton made at the same time and from the same lot of material, may spot very closely on a smooth curve. However, there will be a slightly greater overall change in the time-current characteristics when the month-by-month and the year-by-year variations are included. This is due to the necessity of permitting reasonable commercial limits in acceptance tests on materials and in the holding of the parts to physical dimensions. Therefore, periodic checking of the melting time-current characteristics is vital to the maintenance of the overall accuracy of fuse links. Such measurements require reasonably expensive equipment. Also exacting care is necessary if errors are not to be introduced.

Accuracy in the total melting time is of little value if a proper balance is not secured between the mechanical (tensile) strength of the link and the possibility of its being partially melted by any current in excess of the rating. Experience has shown that when mechanical strength is made the primary requisite, the fuse links (employing any fusible metal) may be damaged by currents capable of melting the link that persist for only 50 to 60 per cent of the total melting time. The standards for fuse links specify a 10-lb. mechanical strength when cold. Assurance is necessary that this can be met during and after many cycles of heating and cooling by periodic loads. Reasonable factors of safety above the 10-lb. minimum can be provided and still permit any current capable of melting the link to persist up to 90 per cent, and with the larger links up to 97 per cent of the total melting time. Such a balance also provides improvement in the impulse blowing characteristics of the fuse links.

Accuracy in the total clearing time-current is as important as in the melting time-current curves. The arcing time, which when added to the melting time gives the total clearing time, is not straight line function, as shown in Fig. 1. The location of the point of the inverted "V" will vary with the bore and length of the auxiliary tube on the fuse link, the size and stiffness of the flexible cable, and other factors of the fuse link design. It is general practice to use only three or four different sizes of auxiliary tubes and flexible cables for a line of fuse links, which produce an equal number of different arcing time curves. All of them are similar in shape to Fig. 1 but with different numerical values. (Generally with the larger sizes the minimum melting current is greater than that at the peak of the inverted "V" and so only the No. 2′ portion of the curve applies.) Because of this, it is of vital importance that total clearing time-current characteristics be determined by tests at rated voltage. Also a maximum number of variables, such as the point of the wave at which the short-circuit is thrown on, the power factor and the rate of rise of recovery voltage must be held as constantly close as is possible to normal operating conditions. These should be at least more severe than those to be met with in distribution systems.

It has been shown in the foregoing discussion that the modern fuse link can be made with an accuracy and dependability undreamed of a few years ago when it was just a piece of wire pulled from a spool. Naturally all of these improvements expand its usefulness as a tool for protecting apparatus and improving service continuity on distribution systems. Utility engineers with a background of 3 or 4 yr. of operating experience with fuse links connected in series at sectionalizing points on their systems report 100 per cent successful selectivity of operation. The better customer relations and the increased revenue thus made possible justifies all of the engineering attention that is making the modern fuse link a reliable instrument. It also opens the way for others who are not already securing the benefits from the modern fuse link to start securing increased returns from their investment in distribution fuse cutouts and fuse links.

Stop Corrosion by Controlling pH

By L. F. WIRTH
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Midland, Mich.

The pH value of the boiler water in a 1250-lb. boiler is an important factor in the control of localized corrosion and sludge composition. By varying the pH value, corrosion can be promoted or stopped, the rate of which can be measured by determining the quantity of hydrogen gas liberated by the boiler with the steam. Sludge composition can be changed from that of a sticky complex phosphate, that builds up on the tubes with serious results, to a simple form of calcium phosphate which is easily removed as suspended matter with the blowdown water from boiler

MUCH has been learned in the past few years regarding the effects of various boiler-water pH values carried in modern 1250-lb. boilers. Some interesting data collected from a 300,000 lb. per hr., 1250-lb. pressure boiler should prove of value to operators of such units. Some of this material may not be according to theory; the results achieved, however, are backed by information collected over a period of 18 mo. of operation.

Influence of pH on Localized Corrosion

The fact that control of pH values will influence corrosion rates is widely known. Dissolved oxygen, present in various types of waters, is less corrosive when the pH value is increased. Corrosion, by dissolved oxygen, in boilers, is therefore kept at a minimum by carrying high boiler-water pH values.

The form of corrosion discussed here is not caused by dissolved oxygen present in the boiler water, but is caused by oxygen supplied at the point of corrosion by breakdown of steam formed on the tube surface. Localized corrosion as here termed, occurs either at areas of high heat input, or in areas of restricted cir-

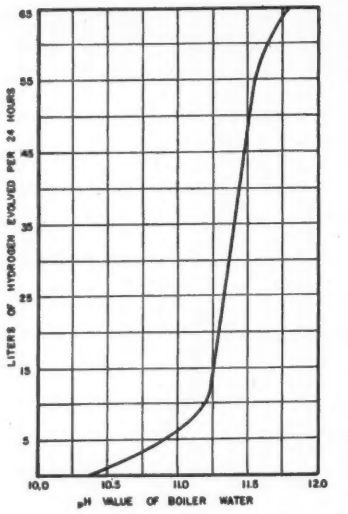


Fig. 1. Relation of hydrogen evolved to pH value of boiler water

culation. It occurs even though the area is surrounded by a boiler water containing sodium sulfite in quantities sufficient for corrosion prevention.

Tube failures occur without rupture of the tube. Pin-hole leaks develop and further attack at this point stops. The size of the leak gradually increases; the increase, however, is due to the erosive effect of the water passing through the hole.

Upon examination, long furrows will be found on the top side of horizontal tubes, and in the case of vertical tubes, it is not unusual to find a spot the size of a half-dollar corroded out to a thickness of 1/16 in. or less at the center. Only in a few cases have tubes blistered from this difficulty, tapping with a hammer being required to locate the pits that have not yet started leaking. The reaction which takes place at this point of attack may best be expressed by the formula

$$3\,Fe + 4\,H_2O \rightarrow Fe_3O_4 + 8\,H$$

Using this reaction as a guide, it is natural to think that hydrogen gas will be in the steam when corrosion is taking place. A trap, or other degasifying apparatus, installed on the steam sampling line coming from the saturated steam header, and operated at a temperature just below the flash point of the condensed steam, can be used to collect the gas. Analysis of the non-condensables must be made to determine the quantity of hydrogen present. The corrosion rate may then be estimated from the volume of hydrogen gas which appears in the steam while the attack continues. The rate of corrosion is influenced by the pH value of the boiler water. The higher the pH, the more aggressive is the action. By lowering the pH, the gas liberation is retarded, and in some cases stopped, indicating a decrease or elimination of the corrosive attack. Boiler design will of course influence this. In some instances, it will only be possible to retard or minimize the attack.

The direct relationship between the hydrogen gas liberated at high pH values, and the decrease in evolution to the point of elimination at pH values below 10.3, is shown in Fig. 1.

The fact that 1 liter of hydrogen gas liberated by the boiler requires that 0.0042 lb. of iron be oxidized shows with what rapidity tubes can be lost. 50 liters of the gas passing from the unit means that more than 0.21 lb. of iron has been destroyed. This metal comes from a few points only, hence, tubes fail in a few days, or less, once the condition starts. Perhaps the formula written above should be made to read

$$3\,Fe + 4\,H_2O + NaOH \rightarrow Fe_3O_4 + 8\,H + NaOH$$

Condensates returned from brine and caustic soda evaporators are used as feedwater to the boiler from which this data has been collected. Considerable leakage of these salts results at times in a feedwater having as much as 15 p.p.m. hardness (calcium and magnesium chlorides) and a pH of 8.5 or more after deaeration. Monosodium phosphate is used to precipitate the calcium and magnesium salts and to help maintain the proper pH value in the boiler water. Occasionally, excessive continuous blowdown, flashed to 400-lb. boilers, is used to further reduce alkalinity.

At pH values ranging from 10.5 to 11.5, continued operation with a clear boiler water regardless of incoming feedwater hardness, was found to be evident. Upon inspection of the unit, very clean drum surfaces were found. By passing a turbine through the tubes, heavy deposits of sludge, weighing as much as 3 lb. per tube, were removed. The composition of this material, which adhered to the tubes, was found to be that of a complex sodium calcium phosphate. X-ray analysis was used to identify this material, however, patterns obtained were not comparable with those of any known material. Molecular consistency has been broken down as follows: 4 moles Na, 5.5 moles Ca, 6 moles PO_4, and some (OH) or some water of crystallization. Magnesium precipitates as hydrate at this pH range.

By reducing the pH to 10.3 or slightly lower, the sludge composition showed a complete change. The boiler water became turbid and remained so. Upon examination of the unit internally, drum surfaces were dirtier and loose material was found in so-called dead spots in the drums. Samples turbined from the tubes weighed but a few ounces, as the precipitated salts were removed by continuous blowdown. X-ray analysis of the material turbined from the tubes showed that the complex phosphate of sodium and calcium no longer existed. Only the hydroxy form was found and also some magnesium phosphate. Spectroscopic analysis of the material verified the X-ray method in also reporting the absence of sodium.

Fig. 2. Upper pattern is that of hydroxy apatite, which forms at pH values from 10.0 to 10.3. Lower pattern is that of complex sodium calcium phosphate, here called UP434 for sake of identification. This appears at pH values above 10.5

X-ray patterns shown in Fig. 2 will, if carefully compared, show the difference as pointed out by this method of analysis. The UP434 printed on the lower pattern is for sake of identification only, it being listed as an unidentified pattern, as no like compound has as yet been found or named.

The conditions stated here are no doubt much worse than those experienced by many operators of 1250-lb. units. The feedwater used is at times inferior to that which could be made by treatment from a lake water for high pressure use. The only advantage that may be claimed is the near absence of silica, which rarely approaches 3.0 p.p.m. in the boiler water. An external method of softening this water will soon be in operation. Excessive quantities of sludge will be removed, and the pH value will be controllable to closer limits.

Keep Your Belt Driven Machines Running

How to get the most out of your belt drives for hard worked, belt-driven machinery in continuous service. Neither leather belts or V-belts are hard to maintain if the simple rules for their care are followed. These rules are easy to understand and observe and if followed are certain to add materially to the life of all types of belts. Proper periodic inspection not only of belts but all types of transmission equipment is of vital importance these war days

By J. R. Hopkins
Engineering Department, Chicago Belting Co.

BELT DRIVEN machines will do all right when operated 24 hr. per day and 7 days a week provided they secure all the power they need. Since the power they need must be transmitted through the medium of the belts and pulleys, it is obvious that these must be kept in good condition if maximum efficiency is to be obtained. To have a machine operate continuously, the belt drive must also operate continuously, and must deliver the full power of the motor or lineshaft to the driven machine.

In general the belt drive that is most satisfactory is one which in the long run will transmit the desired power at the lowest cost. Included in the total cost of the belt are the following elements: the initial cost; the cost of repair and maintenance; and the loss caused by the loss of production due to machinery shutdowns as a result of failure of belts during working hours. While the latter is extremely obvious, it is often neglected when figuring belt costs and it is for this reason that the point is emphasized here. In many instances this item is the most important of the three. This is especially true in cases where the driven machine has a high earning power.

To reduce belt costs due to loss of production through belt failure it is important to provide for regular inspection of all belts and pulleys in a plant. After belts have once been properly installed they should be checked regularly to make certain that the proper operating conditions continue to prevail.

Neither leather belts or V-belts are hard to maintain if the proper rules for their installation and maintenance are understood and adhered to. The rules listed below are simple and easy to understand.

How to Get the Most Out of Leather Belts

1. KEEP THE BELTS DRESSED.

Leather belts *must* be kept dressed—to prevent their fibres drying out. And keep them *clean*. Dress with good leather belt dressing every 3 mo. for ordinary conditions—every month or every week where air is dusty, very dry or where belts are overloaded. To clean a belt wipe off dirt with waste dipped in gasoline. Let belt dry. Then dress it. Naphtha or carbon tetrachloride are also good.

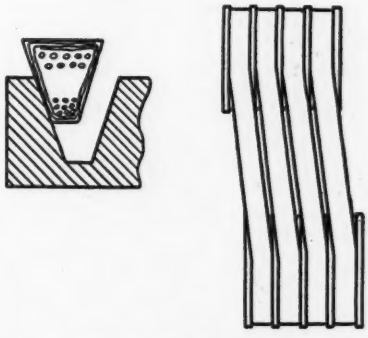


Fig. 1. Diagram of V-belt drive showing the effect of misalinement. If a multiple V-belt drive is misalined a little reflection will show that the belts are scraping down one side of the grooves as they enter the driven pulley and similarly scraping down the other side of the grooves where they enter the driver. This constant scraping action tends, greatly, to reduce the belt life

2. MAKE ALL YOUR LEATHER BELTS ENDLESS.

They last longer. And avoid fastener trouble. Your millwright can be taught how to make endless laps by your nearest belt shop. Or your belt supplier will do it for you. If you have many leather belts buy clamps and rods and ask for book of instructions. Then you

	SINGLE PLY		DOUBLE PLY			TRIPLE PLY	
	Med.	Heavy	Light	Med.	Heavy	Med.	Heavy
	These are the minimum recommended pulley diameters for the above thickness belts						
Belts Under 8" Wide	3"	5"	6"	8"	12"		
Belts 8" and Wider			8"	10"	14"	24"	30"

Table I. Minimum Pulley Diameters for Leather Belts of Different Thicknesses

Table II. Motor Manufacturer's "Standard" pulley diameters for different motor speeds and horsepowers*

Frame No.	3600 RPM	1800 RPM	1200 RPM	900 RPM	720 RPM	600 RPM	Standard Pulley		
							Dia.	Face	Bore
202		¾	½				3	3	¾
204	1–1½	1	¾–1	½			3	3	¾
224	2–3	1½	1½	¾	½		4	3½	1
225		2		1			4	3½	1
225	5	3	2		¾	½	4	3½	1
254				1½	1	¾	4½	4½	1⅛
254	7½	5	3	2	1–1½	¾	4½	4½	1⅛
284	10	7½	5	3	2	1½	5	4½	1¼
324	15						5	6¾	1⅝
324		10	7½	5	3	2	6	5½	1⅝
326	20						5	6¾	1⅝
326		15	10	7½	5	3	8	6¾	1⅝
364		20					9	7¾	1⅞
365			15	10			9	7¾	1⅞
365		25			7½	5	9	7¾	1⅞
404			20	15	10	7½	10	7¾	2⅛
405		30			15	10	10	7¾	2⅛
405			25	20			10	7¾	2⅛
444		40			20	15	11	9¾	2⅜
444			30	25			11	9¾	2⅜
445			40	30	25	20	11	9¾	2⅜
504			50	40	30	25	12	11	2⅞
505			60		40	30	14	13	2⅞
505				50			14	13	2⅞

*The National Electric Manufacturers' Association (NEMA) lists standard pulley sizes which are the smallest diameters that should be used with their motors for all-around good results. So the first step toward getting a good drive is to select a driving pulley large enough for its job.

Table III. Belt Speeds in F.P.M. for Different Pulley Diameters and R.P.M.*

Pulley Diam. Inches	SPEED OF PULLEY—R.P.M.							
	3450	1750	1150	850	690	575	490	435
1½	1354	687			BELT SPEED F. P. M.			
2	1805	916	602					
2½	2257	1145	753					
3	2708	1374	903	667				
3½	3160	1603	1054	779	632			
4	3611	1832	1204	890	721	602		
4½	4062	2062	1355	1001	810	677		
5	4514	2291	1505	1113	902	752	642	
5½	4965	2520	1656	1224	992	828	706	
6	5417	2749	1806	1335	1082	903	770	684
6½	5868	2978	1957	1447	1171	978	834	741
7	6319	3207	2107	1558	1261	1054	899	798
7½	6771	3436	2258	1669	1351	1129	963	855
8	7222	3665	2408	1780	1441	1204	1027	912
8½	7674	3894	2559	1892	1532	1279	1091	969
9	8125	4124	2709	2003	1622	1355	1155	1026
9½		4353	2860	2114	1715	1430	1220	1083
10		4582	3010	2225	1800	1505	1284	1140
10½		4811	3161	2337	1892	1580	1348	1197
11		5040	3311	2448	1980	1656	1412	1254
12		5498	3612	2670	2161	1806	1541	1368
12½		5727	3763	2782	2256	1881	1605	1425
13		5956	3913	2893	2342	1957	1669	1482
13½		6185	4064	3004	2435	2032	1733	1539
14		6414	4214	3115	2522	2107	1797	1596
14½		6644	4365	3227	2617	2182	1862	1653
15		6873	4515	3338	2705	2258	1926	1710
15½		7102	4666	3449	2800	2333	1990	1767
16		7331	4816	3560	2882	2409	2054	1824
16½		7560	4967	3672	2973	2484	2118	1881
17		7789	5117	3783	3062	2559	2182	1937
17½		8018	5268	3895	3158	2634	2247	1994
18			5418	4006	3240	2710	2311	2051
18½			5569	4117	3338	2785	2375	2108
19			5719	4228	3422	2860	2439	2165
19½			5870	4340	3518	2935	2503	2222
20			6020	4451	3605	3011	2568	2279
21			6321	4673	3793	3161	2696	2393
22			6622	4896	3965	3312	2824	2507
23			6923	5118	4150	3462	2953	2621
24			7224	5341	4330	3613	3081	2735

*Experience shows that the most satisfactory and cheapest belt drives are those with belt speeds from 3500 to 4500 f.p.m. With them narrower belts and pulleys can be used. Lower bearing pressure is required, belt life is longer, and generally more satisfactory operating results are assured.

can make belts endless on the pulleys. Metal fasteners constitute the weakest part in any belt and a belt is no stronger than its weakest part.

3. Be Sure Your Belt Thickness Is Correct for Pulley Diameter.

There are minimum pulley diameters for leather belts of different thicknesses. These are shown in Table I. Do not use on pulley smaller than in this table or you will have trouble.

4. Be Sure Your Belt Is Right Size for the Load.

To have belt driven machinery work properly the machine must be provided with enough continuous and dependable power to handle all peak loads—no matter how frequent or severe the loads are. This means the full power of the motor or the line shaft must reach the driven machine through the belt *and you must provide enough belt for this purpose.*

Lineshaft Belts and Long Center Drive Belts

If any such driven machine does not work perfectly first check the belt size. Ask any belt maker for the American Leather Belting Association 1939 horsepower table. Check the width and thickness of your belt with this table. If your trouble is real or continuous this will probably correct it.

Short center leather belt drives are recommended only with an automatic belt tightening motor base (pivoted motor bases) used in place of motor slide rails. With these bases the leather belt is very efficient, the belts last a long time and there is practically no drive maintenance required.

A. Ask your belt supplier for a Short Center Leather Belt Drive Data Book. Gives complete tables so you can quickly and easily check any short center leather belt drive. Is very complete and dependable.

B. Be sure you have large enough pulleys to keep the belt speeds up. Doubling the belt speed doubles the hp. a belt will transmit or cuts in half the stress in the belt for the same hp. Be sure that your motor pulley is not smaller than the diameter recommended by motor manufacturer. Nearly all unsatisfactory drives get that way because the small pulley is too small. See table for minimum diameters for NEMA motors.

Use the Short Center Leather Belt Drive Data Book as your *bible.* If you do every such drive will be satisfactory, the drives will require scarcely any maintenance and the belt life will be very long.

If it ever develops that you have to change over a V-belt drive to a leather belt drive this data book tells everything you need to know, installation is easy and can be done quickly.

1. In designing new installations always use larger sheaves than minimum recommended and use an extra belt or two above the minimum number recommended.

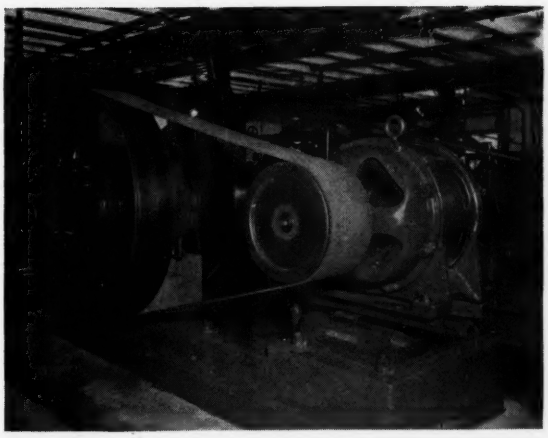


Fig. 2. (Above) A closeup view of a 14 by 10 in. compressor with 75-hp. automatic belt tightening motor base drive with leather belt in the plant of a car manufacturer in New Jersey. The motor pulls into the belt under load and slacks off on the belt when idling or not running

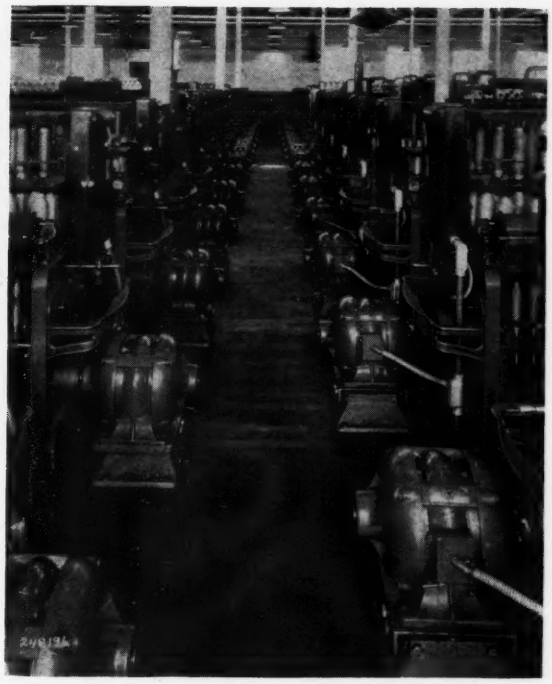


Fig. 3. (Right) Cotton mills generally have adopted the automatic belt tightening motor base drive to secure more production and a better quality yarn

Additional material and cost is offset by considerably longer life.

2. Be sure to purchase *matched sets* of belts so that each belt will carry its full share of the load.

3. Don't force or pry the belts over the sides of grooves. Slide motor forward to put the belts on and then slide back to give tension. Better yet use a pivoted motor base under the motor and belts will go on easily and always be at the right tension when running.

4. Proper alinement of sheaves is very important to long V-belt life. Be sure the sheaves are lined up in both horizontal and vertical planes.

5. KEEP V-BELTS TIGHT — V-belts need correct tension the same as other belt drives. If no pivoted base is used check tension 36 hr. after original installation and at frequent intervals thereafter check to make sure they have live, springy vibration when struck by hand.

6. Check sheave grooves to make sure they are smooth and not worn out of shape. If they are, replace with new sheave.

7. KEEP V-BELT CLEAN—free from dirt, grease and oil. No belt dressing necessary. Just wipe with cloth or waste dipped in gasoline.

8. Never replace part of a set of V-belts with new ones. Replace the whole set with new V-belts and save the old ones for spares to be used with other old ones.

PROMOTIONAL DATA FOR PAYROLL SAVINGS

FOLLOWING a broad program to put the power of an organized promotional campaign behind the Payroll Savings Plan, the U. S. Treasury Department has made available to nearly every business firm in the country a complete set of promotional material.

All this material is designed to help business firms achieve more quickly the goal of at least 10 per cent of payroll invested in War Savings Bonds.

Nearly 100,000 of the nation's business firms have already installed, and are operating under, this plan which permits systematic purchases of War Bonds by employes through voluntary allotments from each worker's pay.

Experience has proved that the Payroll Savings Plan is most effective when stimulated by a well planned, fast-moving program to explain the operations and benefits of the plan and see that it is properly sold to each employe.

Accordingly, the War Savings Staff, with the voluntary assistance of some of the nation's ablest advertising and merchandising men, has prepared and made available complete sets of material that will assist every company in putting on a sustained and successful drive.

One book outlines the basis for the overall campaign and explains the general material available.

A basic book for the employe is one which explains how money saved by workers is of vital importance in winning the war; it drives home the sound practical benefits each worker will gain by having a reserve fund saved up for the postwar years. It also answers questions that may be in the worker's mind as to the value of War Bonds as an investment.

To give each worker tangible evidence of his part in this All America program, lapel buttons and window stickers are furnished reading, "I am buying at least 10%."

When the entire business has signed up for a minimum 10 per cent payroll, it is authorized to acquire and display the official Treasury Department Target Flag.

This material is distributed through the offices of the War Savings Staff's State Administrators. Any company desiring to get a plan rolling at once is invited to call their local State Administrator's office and request quantities as needed.

DIESEL POWER For A Small Factory

Installation of a 210-hp. Diesel engine in the plant of the Geyer Manufacturing Co. at Rock Falls, Ill., pays for itself in 5 yr. as a result of the savings effected over previous power costs. Even with a high fuel cost of 5.26 ct. per gal. and a load factor of only 40 per cent power is produced at a total production cost of 7.4 mills per kilowatt-hour. The accomplishments in producing a source of cheap and reliable power at this plant should be of interest to many small industrial plant operators. This plant produced 10.3 kw-hr. per gal. of fuel

By William H. Gottlieb

THESE are increasingly difficult times for the small producer of non-defense commodities. Raw material priorities rulings may limit his volume of production and he knows that priorities can apply to the power supply as well. To protect against any possible deprivation of his vital power supply, many a manufacturer has invested in the safety of his own power plant. The traditional reason for installing a Diesel plant is to secure economy of power production and this factor carries added weight today.

The Geyer Manufacturing Co. of Rock Falls, Ill., manufacturer of hand garden tools, was concerned primarily with the problem of reducing power costs when it installed a 210-hp. Buckeye Diesel engine in September, 1940. The result has been a total production cost of 7.4 mills per kw-hr. and the clear promise of even lower costs in the future. Savings effected as compared with previous power costs have been sufficient to pay off the entire cost of the plant in 5 yr.

There are several important factors that make economical power production at the Geyer plant extremely difficult. First, the fuel cost is high, 5.26 ct. per gal. The second difficulty is a poor load factor which averages only 40 per cent of the engine capacity. This means a variable load which periodically requires a major portion of the engine's power but drops to a low point in the intervening periods. Stamp presses, grinding machines and elevators provide a bumpy load. Finally, the plant operates at present only 40 hr. a wk. and it is usually the well loaded, steadily operated Diesel that sets the record.

In view of these conditions the Geyer plant already has recorded highly creditable performance figures. Table I gives operating data for the full history of the plant from October, 1940, the first full month of operation, through September, 1941. Total kilowatt-hour production for the 12 mo. period was 147,860. Despite the unfavorable load factor, the plant showed as high as 11.4 kw-hr. per gal. of fuel consumed and the average was 10.3. The engine returned, on the average, better than 3800 hp. hr. per gal. of lubricating oil and this includes a quantity of oil drained from the crankcase and put aside for later reclamation. There were no additions to the company payroll to provide an operator for the Diesel, but Howard A. Geyer, president of the company, believes in conservative bookkeeping and charges the Diesel plant with part of the wage of a regular employe who starts and stops the engine and gives it occasional attention. The operating costs given in Table I include fuel, lubricating oil, labor, water treatment and maintenance. It will be seen that the cost per kw-hr. fell from .1 ct. in the first month of operation to a low point of 5.6 mills in June. Now that the break-

Operating Data and Costs for the period from Oct., 1940 to Sept., 1941

Months	Kw-Hr. Generated	Hr. Operated	Gal. Fuel	Gal. Lube	Load Factor	Oper. Cost per Kw-Hr.	Operating Cost
1940					%		
October ...	11,071	218:30	1,158	8¾	32.5	.0104	115.43
November..	12,391	190	1,135	6¼	41.8	.0079	98.47
December..	13,455	197	1,204	...	48.7	.0063	84.78
1941							
January...	14,204	221:30	1,450	...	45.8	.0077	109.47
February...	13,783	210:15	1,378	3	46.9	.0073	100.49
March	14,770	225:30	1,545	5	45.8	.0071	105.30
April	13,425	210:15	1,175	75	45.6	.0081	109.20
May	12,953	208:45	1,135	23	44.3	.0058	75.72
June	11,140	183:30	1,070	6	43.3	.0056	62.70
July	8,916	165:45	1,050	4	38.4	.0081	72.75
August ...	10,404	202:30	1,010	2	36.7	.0071	74.66
September..	11,348	196:45	1,070	...	41.0	.0069	78.55
Totals ..	147,860	2,430:15	14,380	133	...	....	1,087.52

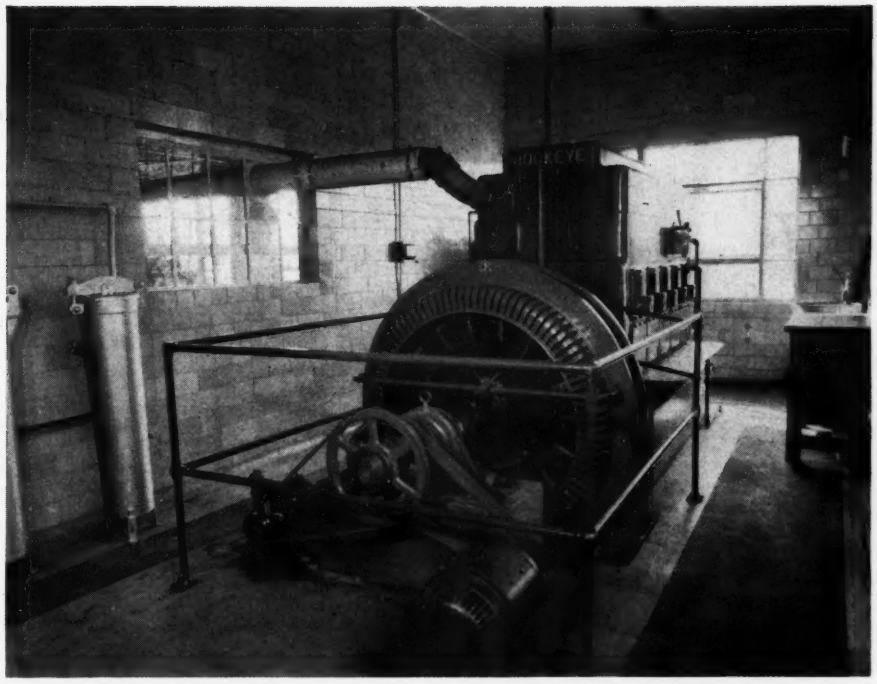
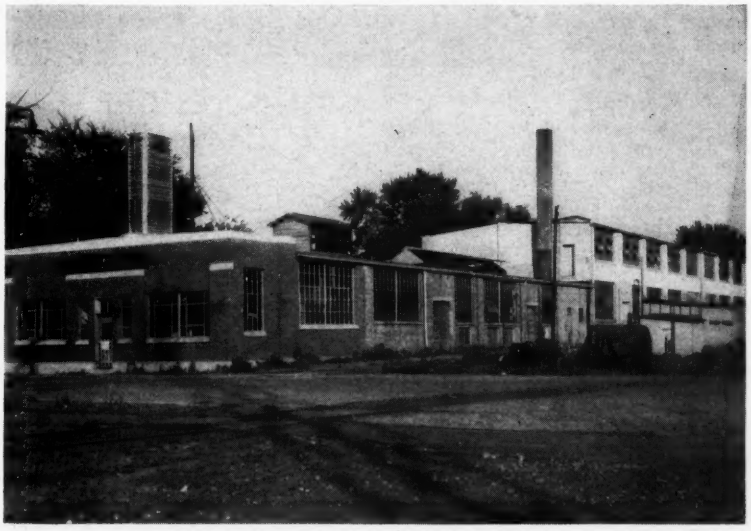


Fig. 1. (Right) This 210-hp. Buckeye Diesel provides all power and light for the Geyer plant and offices. The exciter at the right and the cooling water pump at the left are driven through V-belts

Fig. 2. (Below) The Geyer Manufacturing Co. turns out garden tools at its Rock Falls, Ill., plant. The cooling tower on the roof serves the Diesel



in period is past, Geyer officials believe they can keep the cost close to this latter figure.

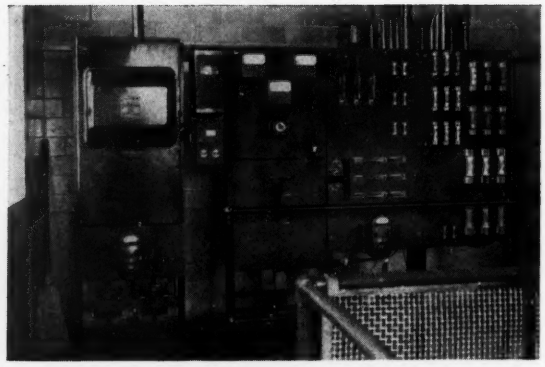
Geyer has a 25-hp. utility line to supply lighting when the Diesel is not in operation, but there is no standby for the main power load. Thus far the company has not lost a minute's service through dependence on the Diesel. The shift from purchased power to Diesel power was accomplished without the loss of a day. There have been no breakdowns and no repairs. It is Mr. Geyer's intention to keep the plant in peak operating condition at all times, first by providing protective accessories, and second by regular inspection of power equipment.

The all-enclosed engine has five cylinders with 10-in. bore and 12-in. stroke and develops its rated 210 hp. at 450 r.p.m. It is a 4-cycle, mechanical-injection Diesel. Driven directly by the engine is a 140-kw., 240 v. Electric Machinery Co. synchronous generator. The 15-kw. exciter as well as a water pump are V-belted to an extension of the crankshaft supported by an outboard bearing.

The fuel used is a Number 2 Diesel oil of 32 to 36 gravity with a cold test of 40 below zero. The fuel is unloaded from tank cars by gravity into a 12,000 gal. underground tank near the company's railroad siding. A motor-driven pump transfers fuel to a 280-gal. day tank underground just outside the engine room. The fuel is filtered and metered before it reaches the day tank. An engine-driven pump draws oil from the day tank and supplies it through a header with branch lines to the individual injection pump for each cylinder. A centrifugal-type governor regulates the quantity of fuel injected.

Soft cooling water is circulated through the engine jackets by the centrifugal pump V-belted to the crankshaft. Leaving the engine by way of the jacketed exhaust header, the water is pumped up over an atmospheric-type cooling tower on the roof. The cooled water drains to a tank inside the building and then flows to the circulating pump suction. Within the engine room is a water softening plant which is used to treat all make-up water.

Lubricating oil is supplied to the bearings and the cylinders by a pressure circulating system in which a gear pump driven off the crankshaft is the key unit. It is the practice at this plant to drain the system every 5 mo. (roughly a 1000 hr. of operation). This oil is being stored and will be reclaimed for re-use in the engine system. A filter set directly in the



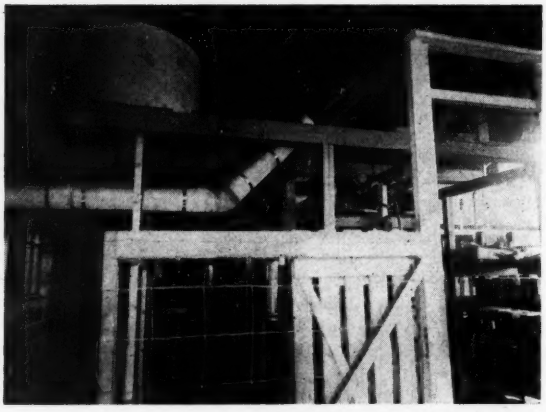


Fig. 3. Make-up water for the engine cooling system is treated in this Servisoft softener

Fig. 4. The switchboard carries a G-E voltage regulator and watthour meters. Other instruments are Roller-Smith

Fig. 5. The exhaust line leads from the engine room at the left to a Burgess snubber near the roof inside the supply room. At the upper left is the tank holding engine jacket water

line of flow serves to keep the oil clean in the course of operation.

Exhaust gases pass from the header through an insulated pipe to the vertical exhaust snubber on a high platform in the supply room which adjoins the engine room. The gases vent to the atmosphere through a pipe extending from the snubber up through the roof. The exhaust heat is used to heat the supply room during the winter months.

Starting air for the engine is supplied by a compressor belted to a 2-hp. motor. Air is stored in two tanks.

Through most of the day the engine operates without attention. From time to time the man charged with operating the plant drops in for a minute, checks the exhaust temperatures by means of an exhaust pyrometer on the end of the engine, glances at pressure gages and thermometers also arranged conveniently for quick inspection. The switchboard with its instruments also gives pertinent data on plant operation. In the event that a dangerous condition should arise while the plant is unattended, the engine is protected by a device which shuts down the engine automatically if either lubricating oil or cooling water pressure fails.

If a power shortage should develop in northern Illinois, the Geyer Mfg. Co. need not worry about priorities. If he is forced to curtail production, Geyer need not worry about high connected load charges. Whatever the situation, this company is assured an abundant and economical supply of power.

PRINCIPAL EQUIPMENT IN THE DIESEL PLANT OF THE GEYER MFG. CO.

Engine	One 210-hp. 5-cylinder, 10 by 12-in., 450 r.p.m., 4-cycle, mechanical-injection, Model 70 Diesel. Buckeye Machine Co.
Generator	One 140-kw., 175 kv-a., 450 v., 422 amp., 3-phase, 60 cycle, synchronous generator with V-belted 15-kw. exciter. Electric Machinery Manufacturing Co.
Governor	Pickering
Fuel	Primrose Petroleum Co.
Fuel Transfer Pump	Geo. D. Roper Co.
Fuel Injection Pumps	Bendix
Lubricating Oil	Texaco Ursa. Texas Co.
Lube Oil Filter	Purolator Co.
Cooling Water Pump	Goulds Pumps, Inc.
Water Softener	Servisoft, Inc.
Exhaust Snubber	Burgess Battery Co.
Pressure Gauges	James P. Marsh Corp.
Exhaust Pyrometer	Alnor. Illinois Testing Labs., Inc.
Voltage Regulator	General Electric Co.
Switchboard Instruments	Roller-Smith Co.
Watt-Hour Meters	General Electric Co.
Safety Device	Silent Watchman. Buckeye Machine Co.
Outboard Bearing	Shafer
Air Compressor	Curtis Pneumatic Machinery Co.
Air Tanks	Wm. B. Scaife & Sons Co.

MOLECULES GET TIRED TOO

EXPLAINING that molecules associated with the production of fluorescent light tire as easily as humans, Dr. N. C. Beese, research engineer of the Westinghouse Lamp Division, recently released results of exhaustive tests he conducted in order to determine the fatigue effect upon molecules when exposed to ultraviolet light.

When molecules of fluorescent materials start to work, they are efficient and highly productive, but over a period of time, under continued exposure, they lose much of that efficiency and tend to slow down. If the molecules are given rest periods in the dark, they regain their original strength, much the same as human beings.

Methods were devised to investigate this phenomenon using organic as well as inorganic substances, liquids as well as dry powders, and both short ultraviolet radiation and longer radiations. Experiments showed that the fatigue was most pronounced with high intensities of irradiation.

As ultraviolet radiations and current density increased, molecular fatigue was more apparent.

REMOVING AIR-BORNE DUST IN INDUSTRIAL PLANTS

In many present-day industrial processes and operations, especially those concerned with the assembly of delicate instruments and in the production of fine textiles, it is necessary to keep the work rooms as free from dust as possible. The principle of electrostatic precipitation has proved very effective in this field. In this article the author describes some of these applications and also discusses the characteristics of the precipitating equipment. The system is purely electrical in its action

By E. H. R. Pegg

Precipitron Section Engineer, Westinghouse Electric & Manufacturing Company

THE ELECTROSTATIC precipitator has been in use for many years in the removal of dust and other solid particles from the stack gases of power plants and other industrial plants. It is only within recent years that the principle of electrostatic precipitation has been applied, commercially, to the removal of atmospheric dust from rooms in manufacturing and processing plants. Today, these precipitators are finding increasing application in the removal of dust in plants devoted to the production of essential war material. Commercially, these precipitators are manufactured under the trade name of "Precipitron."

The Precipitron operates on the well known principle that a solid or liquid particle suspended in air may be given an electrical charge and then due to that charge may be removed from the air by attracting it to a charged collecting electrode whose charge is opposite in sign to that of the charge on the particle. The Precipitron consists of three essential parts:

1. An ionizing unit consisting of a fine wire at high, direct current potential and two grounded electrodes, which creates a non-uniform electrostatic field in which the foreign particles in the air are given a charge, or "ionized."

2. A collector cell consisting of a system of parallel metallic plates so arranged that a high uniform voltage gradient exists between each pair of plates. As air passes between the plates the charged particles are repelled by plates having the same sign as that of their charge and attracted by those having the opposite sign.

3. A power pack consisting of transformer, rectifier and capacitor to supply high voltage direct current potential to the ionizers and collector cells (Fig. 1).

Fig. 1. (Below) Power pack capable of supplying energy to as many as 50 Precipitron cells

Fig. 2. (Right) Precipitron cell capable of cleaning 750 cu. ft. of air per min.

The ionizing unit and collector cell are combined into a single casing (Fig. 2) which has a cross sectional area of 2 sq. ft. and is rated at 750 c.f.m. These cells may be readily stacked in a ventilating duct (Fig. 3) so as to clean any given volume of air. As many as 50 cells may be energized from one power pack. Power requirement is very low, in the order of .01 to .02 kw. per 1000 c.f.m.

The cells are cleaned by periodically flushing them with water. The accumulated dirt is permanently disposed of by being carried into a sewer with the flushing water through drains in the duct provided for that purpose. The length of the time between cleaning periods varies from 2 to 8 wk. or more depending upon the amount of dirt in the air which may vary from locality to locality and from season to season.

The Precipitron removes smoke particles as small as 0.1 micron in diameter, which pass through the conventional air filter. The effi-

ciency of the unit is measured by the discoloration or "blackness test" method is 85 to 90 per cent depending upon the volume rating of the cells. Conventional types of air filters have efficiencies of 15 to 25 per cent when tested on the same basis.

Modern windowless war manufacturing plants are springing up all over the country. Some of these plants will operate more efficiently and economically because of the air which ventilates them will be cleaned by the Precipitron. Twenty-four hour artificial lighting is a necessity in such a building. This lighting will be more efficient if the Precipitron is used to free the air of dirt and dust particles which otherwise would collect on lamps and fixtures and which, floating in the air, tend to disperse and scatter light. It is also necessary to remove the dirt generated inside the building, such as the smoke and oil mists resulting from high-speed cutting, machining and grinding operations and the fumes from welding operations. This inside dirt can be removed from the building by diluting it with large amounts of outside air—providing the outside air is cleaner at tremendous heating cost in winter and cooling cost in summer. Or it can be removed by re-circulating the air through the Precipitron at a great saving in heating and cooling cost: At the same time the small percentage of make-up air required will be also thoroughly cleaned.

This point is illustrated in the series of photographs in Figure 4. All photographs were made under the same conditions of film exposure and lighting. A 3600 cu. ft. room was illuminated by five overhead fixtures each containing a 200 watt lamp. For photographic purposes a 40-w. lamp in an enameled reflector was suspended above the desk. Air was supplied to the room at the rate of 1200 c.f.m. or at the rate of one complete air change every 3 min. Smoke was generated inside the room by dropping oil on a hot plate and dispersed throughout the room by a fan. Photos A to F of Fig. 4 show the results of varying amounts of make-up air with and without benefit of the Precipitron; in photos A and B, 330 c.f.m. or 27.5 per cent make-up air was used. A definite haze can be seen over the desk in photo A while none is present in photo B. When the make-up air was reduced

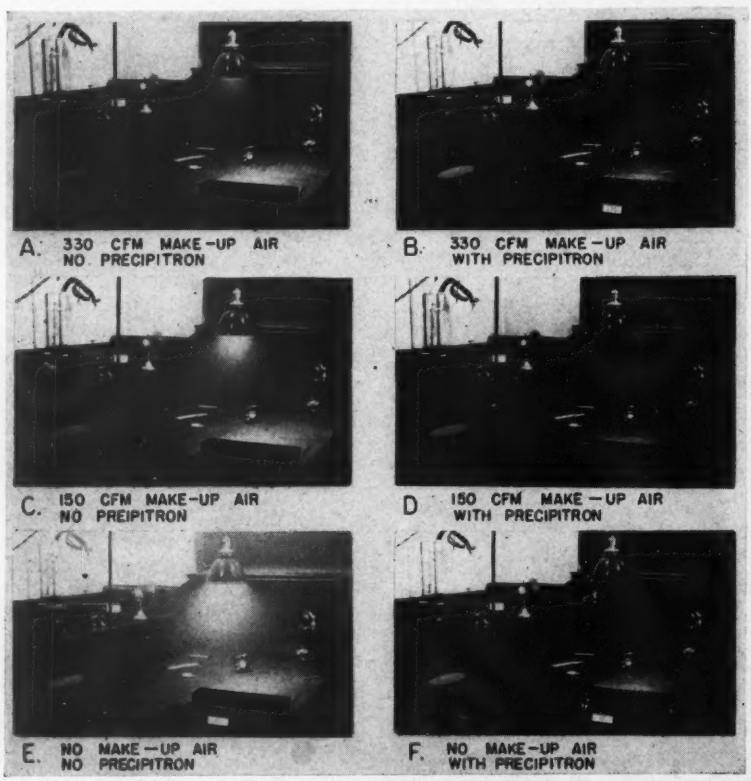

A. 330 CFM MAKE-UP AIR NO PRECIPITRON
B. 330 CFM MAKE-UP AIR WITH PRECIPITRON
C. 150 CFM MAKE-UP AIR NO PREIPITRON
D 150 CFM MAKE-UP AIR WITH PRECIPITRON
E. NO MAKE-UP AIR NO PRECIPITRON
F. NO MAKE-UP AIR WITH PRECIPITRON

Fig. 4. Views showing the effect of the Precipitron upon air in a smoke laden room with varying amounts of make-up air

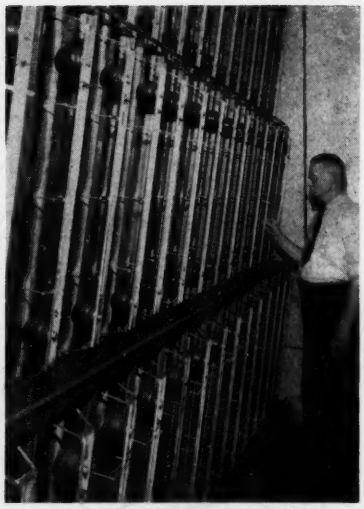


Fig. 3. Interior of a ventilating duct showing the "ionizing" or incoming air side of the Precipitron cells

to 150 c.f.m. or 12.5 per cent, the haze increased considerably in photo C but no increase is apparent in photo D. When no make-up air was supplied the smoke became unbearable as shown by the haze in photo E while little if any increase in haze is apparent in photo F. To achieve the same result as in photo F by dilution only, it was necessary to supply 1100 c.f.m. or 92 per cent make-up air.

The effectiveness of the Precipitron in removing smoke from air is demonstrated visually in Fig. 6. This photograph was taken in a smoke-filled room with no illumination except a projection lamp whose beam was passed just above the air outlet of the Precipitron in the center of the photo. Observe that the light beam effectively disappears as it passes through the clean air emerging from the outlet. This striking phenomenon demonstrates visually the efficiency of the unit in that the air cleaned by it contains very few particles to reflect light from the beam as compared to the surrounding air in which the beam is quite visible.

The Precipitron is being applied daily to air cleaning problems in industry where ultimate cleaning efficiency is necessary to keep men, machines, and equipment at their top efficiencies. It is assisting in the production of the vital materials, steel and aluminum, by keeping free from dirt the air which ventilates mill drive motors and auxiliary equipment. The air in and around mills is laden with smoke and dirt, most of it abrasive or metallic, which if allowed to get into the windings of a rotating machine will even-

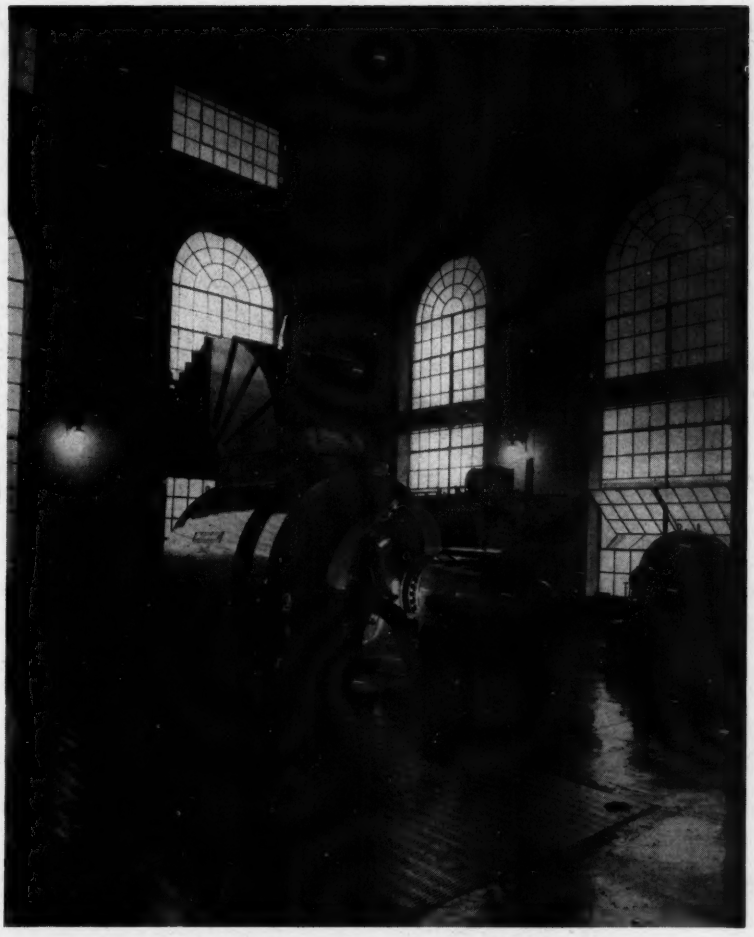


Fig. 5. The ventilating air of this synchronous condenser is kept free of dirt and dust by means of the Precipitron

tually put that machine out of service, and necessitate large scale maintenance operations.

Bombsights are now being manufactured and assembled in plants kept free of dirt and smoke. The degree of accuracy and precision which must be maintained in such an instrument, and the care with which the final assembly is made to exclude from the optical system foreign particles which might settle out to fog the lenses, necessitates a very high degree of air cleaning as provided by the Precipitron.

Better textiles are being produced in textile mills where smoke and soot are removed from the ventilating air. Twisted-in dirt, long a serious problem in spinning mills, has been practically eliminated. (See Fig. 7.) Losses on dirt-soiled yarn in dying processes have been greatly reduced. As a result, streaks in woven fabrics are virtually eliminated and the yardage of top-priced whites, bleaches, and pastels is increased.

Numerous other applications in various fields of industry prove that Precipitron is contributing to wartime production by providing really clean air on which men and machines are operated at top efficiency.

SUBSTITUTE METALS IN LIGHT BULBS

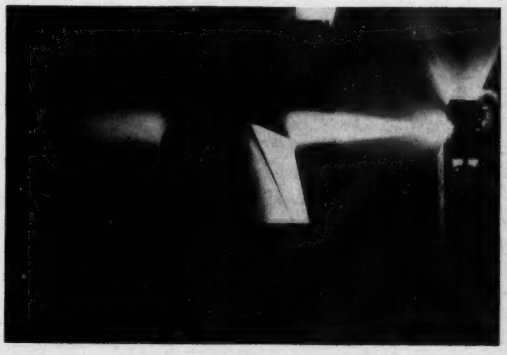
SUBSTITUTION of iron bases and other conservation measures now being put into effect will save approximately two million pounds of brass a year, according to A. E. Snyder of the Westinghouse Lamp Division. Materials to replace vital war metals will be used in millons of Westinghouse lamps in 1942 in order that production of light bulbs for essential civilian needs may continue during the coming year.

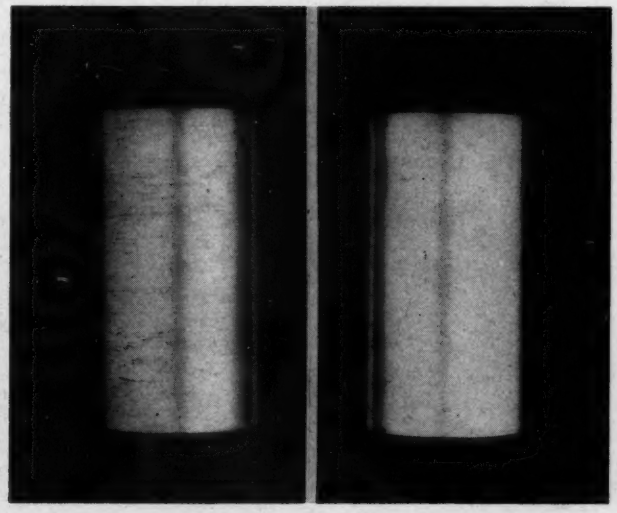
All civilian lamp bulbs in the 10-watt to 300-watt sizes and most industrial lamps will have iron instead of brass bases this year. To prevent corrosion, these bases will be protected with a brass coating.

Nearly all nickel consumption for lamp manufacturing has already been eliminated by the use of nickel-plated iron wire instead of pure nickel wire.

Fig. 6. (Below) Another view showing the effectiveness of the Precipitron in removing smoke from air

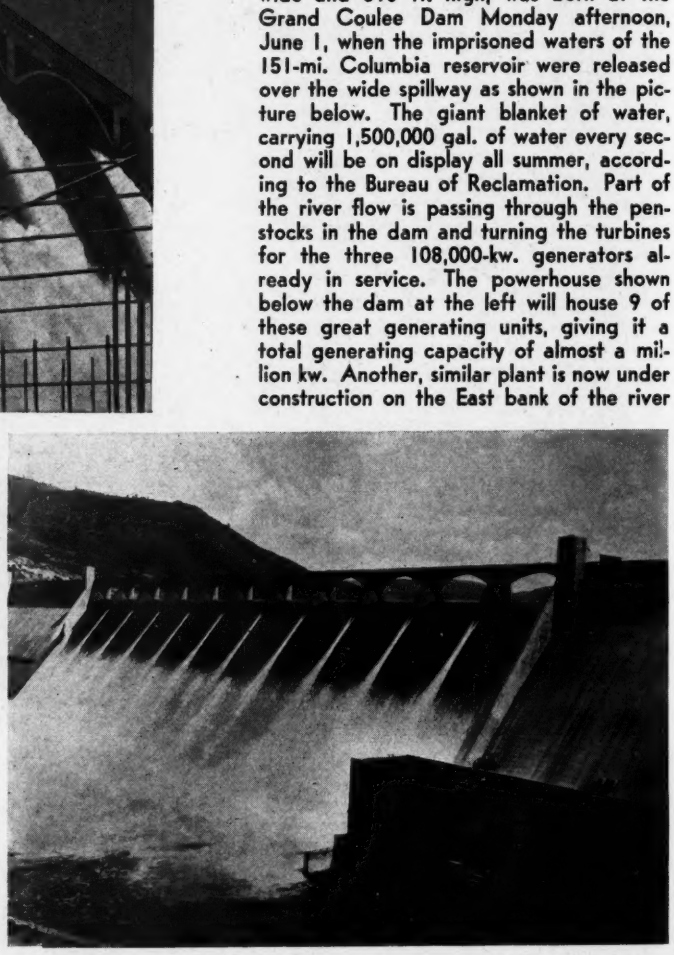
Fig. 7. (Right) Two views of spools of rayon yarn showing how the Precipitron removes dirt from the air in the rooms in which such yarn is wound





PICTURES

One of the world's largest waterfalls, 1650 ft. wide and 310 ft. high, was born at the Grand Coulee Dam Monday afternoon, June 1, when the imprisoned waters of the 151-mi. Columbia reservoir were released over the wide spillway as shown in the picture below. The giant blanket of water, carrying 1,500,000 gal. of water every second will be on display all summer, according to the Bureau of Reclamation. Part of the river flow is passing through the penstocks in the dam and turning the turbines for the three 108,000-kw. generators already in service. The powerhouse shown below the dam at the left will house 9 of these great generating units, giving it a total generating capacity of almost a million kw. Another, similar plant is now under construction on the East bank of the river

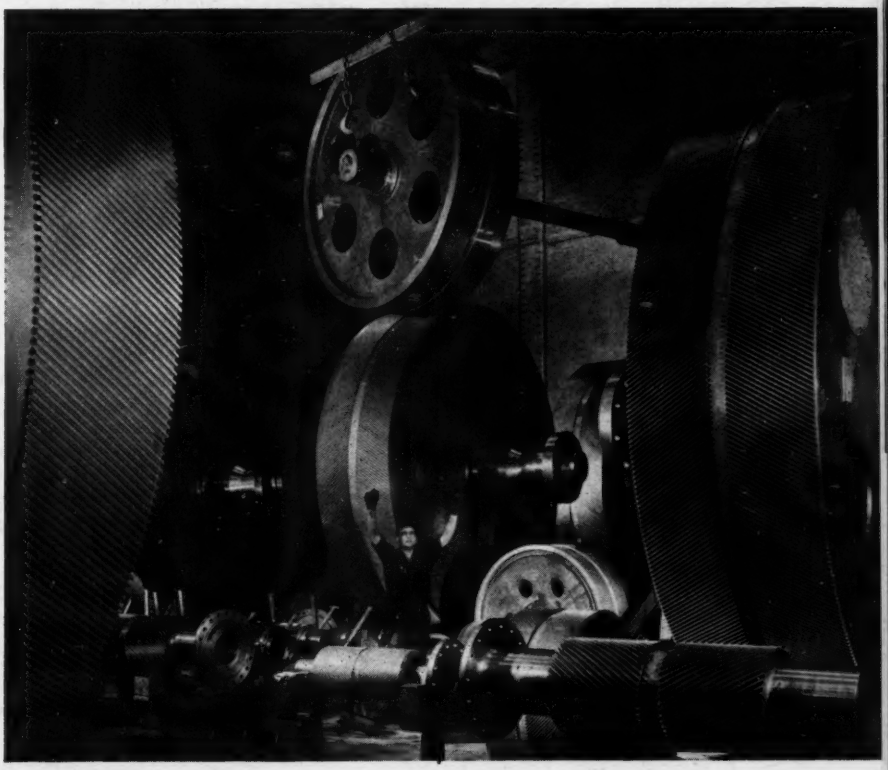


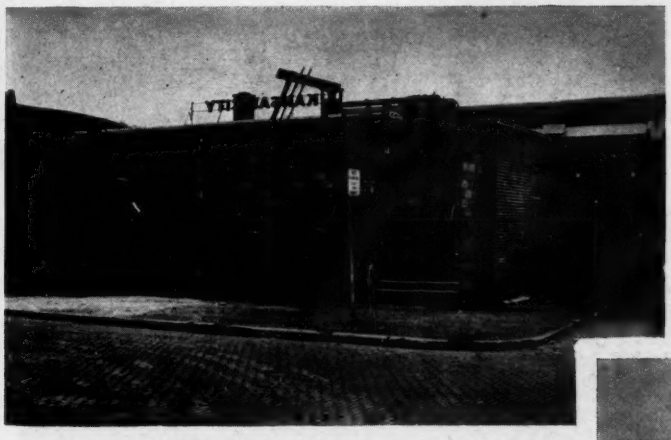
The threatening tumult of the mighty Columbia as it plunges 325 ft. over the giant spillway of Grand Coulee Dam holds no fear for the workmen shown above. They are weaving a network of reinforcing steel for the concrete of the East powerhouse. The new powerhouse is now about 65 per cent completed and will be similar in design and capacity as the West powerhouse

Mirror of cast iron. This giant mirror of cast iron will support the two million pounds of rotating machinery in one of the 108,000-kw. vertical waterwheel generators for Grand Coulee power plant. This picture taken in the shops of the Westinghouse Electric and Manufacturing Co. shows the beautiful finish resulting from completely machining, lapping with abrasive compound, and polishing. Weighing 9700 lb., this thrust runner plate is 8 ft. in diameter, 6 in. thick and has a 38-inch bore. It will be used to support the generator rotor, waterwheel propeller and shaft. Inspecting the huge bearing are, from left to right: L. W. Landeck, junior engineer, W. K. Orr, assistant general inspector, generator works department, Charles Prengaman, machine tool operator, W. S. Oswald, general inspector, generator works department, all of Westinghouse

# of Engineering Interest

The extreme accuracy of large gears for marine propulsion equipment and the care required in manufacturing them is not generally appreciated by those who do not have occasion to see them in the process of manufacture. The impressive photograph at the right was taken in the shops of the General Electric Co. It shows some of the different types of gears and pinions used to translate the high r.p.m. speed of the propulsion turbines into slower, efficient propeller speeds. The workman is directing the overhead crane removal of a high-speed gear blank to a hobbing machine that will cut teeth into its circumference. The larger gears shown are low speed, or bull gears. The rough and finish cutting of such large gears requires 10 or 11 days and the finish cuts must be made without interruption. An auxiliary power supply as well as duplicate lubricating system is always provided for emergency if the main supply fails. At the General Electric plant, three shifts a day maintain an accelerated production program that speeds the flow of gears and other equipment for merchant bottoms from shop to shipyard





To take the place of costly, short-lived sandbag barricades for sabotage protection around power transformers, substations and other vulnerable public utility and industrial equipment, The Celotex Corporation of Chicago has devised an economical wall of lightweight concrete blocks filled with sand. Several utility companies already have adopted this method of protection. Blocks for the walls are made with Celocrete Lightweight aggregate, an expanded slag

As shown above, tests have demonstrated that a wall of 12-in. hollow blocks filled with sand will stop high-powered .30 calibre military rifle and machine gun fire at distances as short as 10 ft. In the test pictured above, 13 shots were driven with a Krag 30-40 rifle firing 180-grain, shell-pointed copper-jacketed bullets. Two shots were fired from a distance of 75 yd., four from 50 yd., five from 25 yd., and two from 10 ft. None of the shots penetrated farther than 9½ inches into the 12-in. wall. The two shots fired from 10 ft. penetrated 8 in. and 6 in. respectively

How to Determine WR^2

Did you ever play "crack the whip" and make the mistake of attaching yourself to too long a line of skaters? You flew off, didn't you? Why? No doubt you have your own ideas about what happened, but, scientifically, what happened was the consequence of your WR^2—your moment of inertia. This is not a discussion of winter sports, but if you are interested in knowing a little more about this mysterious WR^2 you will be interested in Mr. Luken's article. He tells about it in simple language and, what's more, shows you how to calculate and measure it. It's quite simple—try it yourself.

By A. F. Lukens **Motor Engineering Department, General Electric Co.**

THE MOMENT OF INERTIA of a driven load is of extreme importance in the proper selection of a motor for those cases where the motor accelerates a heavy load or makes frequent starts. Prime examples are motors for rapid reversing service, extractors, and at the present moment, air raid sirens. Determination of the moment of inertia is not difficult, but is often neglected because of lack of familiarity with a suitable method.

In engineering work the moment of inertia is expressed as WR^2 in terms of pound-feet squared. These units then are commensurate with the other engineering units of pounds, feet, horsepower, etc.

WR^2 can be determined in three ways, (1) by calculation (that need not be too precise to be useful), (2) by measured comparison with an easily computed object, and (3) by direct measurement. Practical instructions for each of these methods are given below.

Calculation of WR^2

WR^2 is the product of the weight of an object and the square of the radius of gyration, or $WR^2 = W k^2$, where W is the weight of the object in pounds and k is the radius of gyration in feet which in turn could be considered an average of the radii from the axis of rotation of each infinitesimal part of the object. The calculation of a relatively complicated object can readily be made by breaking it up into its simple components, easy to calculate in themselves. Most rotating objects can be broken down to a series of rims, spokes, and disks. Since the WR^2 of the segregated parts add directly to give the WR^2 of the whole, provided a common axis is considered in all cases, each part can be considered in its simplest geometric form.

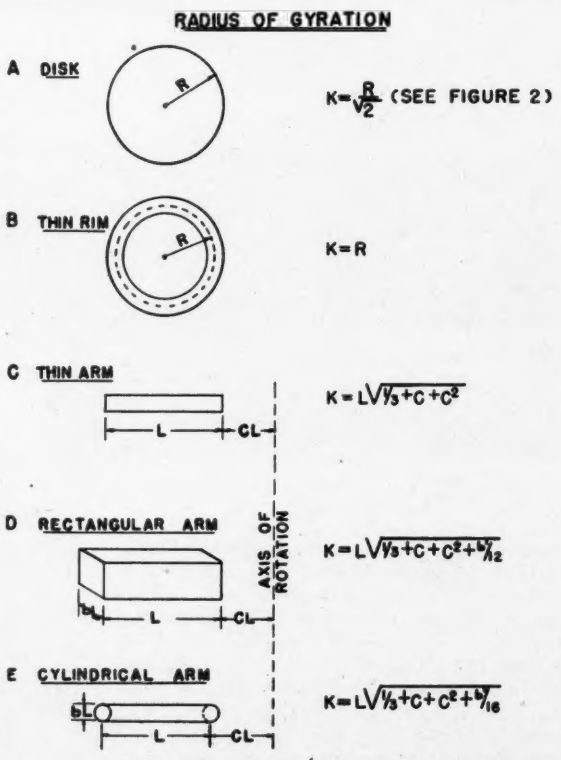


Fig. 1. Radius of gyration for various shaped objects

Figure 1 shows the five basic components and their radii of gyration, k in inches.

Figure 2 shows the WR^2 of disks, which can be used to determine the WR^2 of thick rims by subtracting the WR^2 of an imaginary disk of the inside diameter from that of a disk of the outside diameter. The common engineering handbooks have many formulas for complicated objects which may prove useful in some cases.

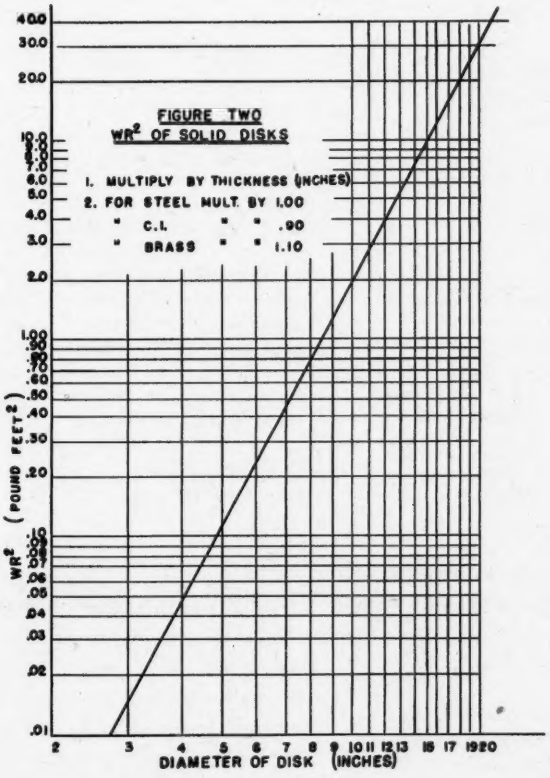


FIGURE TWO
WR² OF SOLID DISKS
1. MULTIPLY BY THICKNESS (INCHES)
2. FOR STEEL MULT. BY 1.00
" C.I. " " .90
" BRASS " " 1.10
WR² (POUND FEET²)
DIAMETER OF DISK (INCHES)

Fig. 2. WR^2 of solid disks

As an example, the calculation of the WR^2 of the flywheel in Fig. 3 is shown. The computation is best carried on in tabular form:

Part	Volume (Cu. in.)	Wt. (lb.)	K (In.)	WR^2 (lb.-in. squared)
Rim	415	106	11	12,800
6 Spokes	103	26	6.2	1,000
Hub	21	5	1.0	5
				13,805

This result, it will be noted, is expressed in pound-inches squared. To get pound-feet squared, it must be divided by 144. Thus:

$$WR^2 \text{ (lb. ft. squared)} = \frac{13{,}805}{144} = 96.2$$

It can be noted that the major part is in the rim and that only this need be calculated even for a fairly close approximation.

WR^2 Measurement by Comparison

Another way of determining WR^2 is by comparison. This method consists of suspending the object

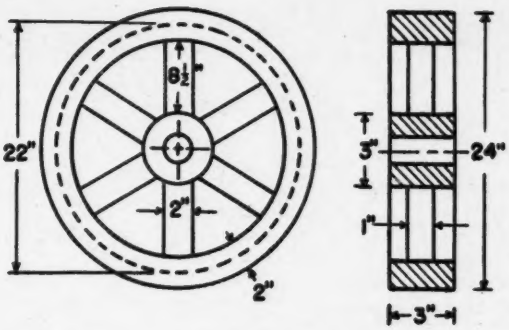


Fig. 3. Flywheel

to be measured from a wire with its axis of rotation coinciding as nearly as possible with the axis or center of the platform, giving it a twist, and taking the time for a given number of complete torsional oscillations. A disk of about the same WR^2 is then suspended, also in balance, from the same wire and the time of the same number of oscillations is measured. The WR^2 of the disk is calculated, say from the chart, and the value for the tested object computed from:

$$WR^2 \text{ (unknown)} = WR^2 \text{ (known)} \times \left(\frac{\text{Time of unknown}}{\text{Time of known}}\right)^2$$

Figure 4 shows the general method. Care must be taken to have the wire long enough to make the time of each oscillation convenient to measure, and to twist the object in such a manner that it rotates about the support as its center. It is also important that the wire be firmly fixed at both ends so that it will not move in the supports, and so that it does not bend at the supports.

Direct Measurement of WR^2

The direct method of measuring WR^2 consists of setting up the object as a torsional pendulum, measuring (1) its time of oscillation, (2) its weight, (3) the dimensions of the supporting means, and (4) computing the WR^2. Figure 5 shows the general set up. This method is perhaps the easiest to use in the field, as any wire, rope, string, or chain can be used as supports if fairly flexible and light compared to the weight of the object. A ruler, a watch, and a set of scales are all that are necessary to take the measurements. If the object is not easily "hooked on to," a light platform can be suspended and its WR^2 determined. The object is then placed on the platform with its axis of rotation coinciding as nearly as possible with the axis or center of the platform, and the total WR^2 measured. The value for the unknown is found by subtracting that of the platform from the total.

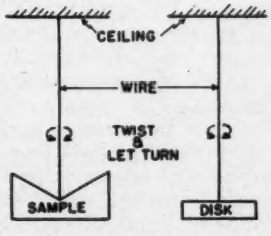


Fig. 4. Measured comparison

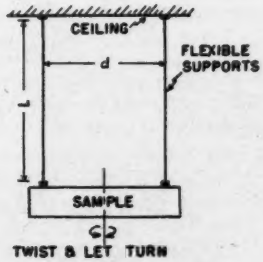
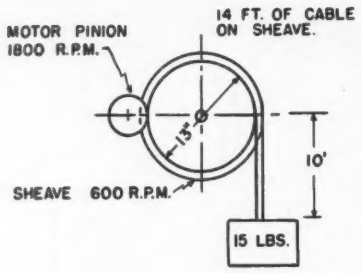


Fig. 5. WR^2 measurement



WT. OF CABLE = 1 LB. PER FT.
WR^2 OF SHEAVE = 18 LB.FT.^{2}

Fig. 6. Relating all WR^2 to one shaft

The time "t" is the time for any convenient number of complete oscillations "N". A complete oscillation is the movement of the object from some one position back to the same position and traveling in the same direction. The computation is made from the formula:

$$WR^2 = \frac{.016\ Wd^2\ t^2}{L\ N^2} \text{ (lb. ft. squared)}$$

where W = weight of object in lb.

d = distance between supports in in.

L = length of supports in in. (should be at least 4 ft.)

t = time in seconds for N oscillations.

Since the location of the decimal point is often confusing it is sometimes wise to make a rough calculation by the curve, Fig. 2, as a check.

Relating All WR^2 to One Shaft

The effectiveness of WR^2 depends upon the speed at which it rotates, so, in any mechanical system with shafts running at different speeds, the WR^2 must be reduced to some one shaft. For motor work, the motor shaft and motor speed is usually used as the basis of comparison. In any event it is always necessary to state clearly to what shaft it is referred, for example "flywheel WR^2 referred to motor shaft." The formula for conversion is:

WR^2 (referred to shaft A) = WR^2 (referred to shaft B)

$$\left(\frac{\text{r.p.m. of B}}{\text{r.p.m. of A}}\right)^2$$

Masses that are part of the system, and that move in straight lines, must also be reduced to the reference shaft. The equivalent WR^2 of the lineally moving mass is:

$$WR^2 = \frac{WV^2}{(2\pi N)^2}$$

where W = weight of lineally moving part in lb.

V = velocity in ft. per min.

N = r.p.m. of reference shaft.

For example, the equivalent WR^2 of the simple hoist shown in Fig. 6 can be calculated as follows:

WR^2 of sheave referred to motor shaft =

$$18 \times \left(\frac{600}{1800}\right)^2 = 2.00$$

WR^2 of cable on sheave referred to motor shaft =

$$14 \times 1 \times \left(\frac{13}{2 \times 12}\right)^2 \times \left(\frac{600}{1800}\right)^2 = 0.45$$

WR^2 of cable and weight (velocity = 2040 ft. per min.) =

$$(15 + 10 \times 1)\left(\frac{2040}{2\pi 1800}\right)^2 = .82$$

Total equivalent WR^2 of system = 3.27 lb. ft.^{2}

The moment of inertia is extremely hard to estimate by merely looking at an object as it varies as the fourth power of the diameter, and at the same time it is an important item of the data necessary to apply a motor to some loads. Therefore, it is hoped that the three methods shown here will be of some help to those who are concerned with seeing that the proper motor, neither too large nor too small, is applied to a machine.

CAPACITORS SAVE $6900 IN FIRST YEAR OF OPERATION

AT THE END of their first 14 mo. operation a group of sixty 15 kv-a. Westinghouse capacitors installed at a southern ore refinery sliced $6900 off the plant's power bill, raised a power factor of 78 per cent to a near unity value of 92, and in the short time of only 14 mo. have completely paid for themselves.

The refinery is entirely electrified, using squirrel-cage induction motors, for the most part, to drive the various equipment. The loading of these motors, due to the nature of the product handled, averages about 66 per cent of their full load rating giving rise to low operating efficiencies with consequent low power factor and heavy lagging currents. The operating power factor of the plant before the installation of capacitors was 78 per cent.

Power Purchased From Local Utility

Power was purchased at 2200 v. from the local utility and was reduced at the plant to 440 v. in their own substation. Charges were based on a monthly kv-a. demand plus an energy rate. Energy in excess of 250 kw-hr. per kv-a. of billed demand was obtained at a rate of 1.5 mil. less than the standard energy rate.

The company management, realizing that raising the plant power factor would increase the number of kw-hr. obtainable at the lower energy rated, and at the same time, reduce the kv-a. demand, decided to install capacitors.

Sixty capacitors, each unit rate 15 kv-a. at 460 v. were installed in distributed banks, one bank to each feeder supplying a low power factor load. The capacitors are in the circuits continuously being switched out only at infrequent intervals for inspection.

Power Factor Rises 14 Per Cent

Results of the installation were noticeable immediately. Load currents on the capacitor equipped feeder circuits dropped. The plant power factor rose from a comparatively low 78 per cent to a near unity value of 92 per cent with a corresponding elimination of useless wattless current. The existing feeders are now capable of carrying enough added load to permit a sizable plant expansion, if and when it should be needed.

Most important, however, was the effect of the capacitors on the power billing. With their elimination of wattless current, the monthly power bill for the first year's operation averaged $575 less than previously. This represents a yearly saving of $6900 in power costs.

The first cost of the capacitors approximated $7800. Slightly more than this amount has been saved in 14 mo. of operation, so that the capacitors have literally "earned their own keep." Since installation, no maintenance or repairs have been necessary.

Unusual conditions surrounding the Riverside Station at Baltimore necessitated a special investigation to determine the allowable stack height, velocity of gases in stack, and plant structural design in order to prevent flue gases from becoming a nuisance[1]

Height of Stacks Established by WIND-TUNNEL TESTS

BY H. L. von HOHENLEITEN[2]
and
E. F. WOLF[2]

BECAUSE of its proximity to a residential area and to the municipal airport, the Consolidated Gas, Electric Light and Power Co. of Baltimore, in the construction of its new Riverside Generating Station, found it necessary to give careful consideration to the flue gas problem and the height of stacks.

Several factors are involved in the design of the Riverside stacks which are different from the usual problem. On account of the induced-draft-fan system, height is not required to produce draft, and with the Cottrell precipitator, the dissipation of flue gases rather than "smoke" is the primary consideration. It is usually desirable to have a stack sufficiently high to be free from smoke troubles under all normal wind conditions.

At Riverside, it was necessary to select a stack height consistent with company requirements for reasonable dissipation of flue gases and yet satisfactory from the viewpoint of air navigation. It was concluded that the proper point of compromise between these contradictory requirements could be found only through the study of models in a wind tunnel.

Elements of the Problem

Three distinct phases of this problem had to be analyzed: (a) It was necessary to establish what wind or weather conditions would produce the most serious smoke annoyance at this station, and, under these conditions, to determine the required stack height; (b) the effect of the addition of successive units to the plant had to be considered; (c) due to stack-height limitations, it was necessary to investigate all possible means of improving the dissipation of flue gases, such as stack design or arrangement, shielding of the stack or building, and increase of stack velocity.

The wind tunnel in the plant now owned by the Allied Aviation Corp. at Dundalk, Md., was used for a 4-mo. period for this investigation. The tunnel, fan motor, and control equipment are installed in a separate brick structure. The tunnel is the recirculating type with double return paths from the discharge side of the fan to the intake end of the throat.

Tests on Riverside Models

Three models of the Riverside generating-station development were tested, namely, a single-unit, a three-unit, and a six-unit model. The latter was regarded as the probable ultimate development at this location. The models were designed for maximum flexibility of operation so that desired test conditions could be obtained readily for the study or demonstration of the effect of any required variable. The models, constructed of wood, were placed on a turntable on a platform erected between the throat and bell of the tunnel. The platform was placed so that the horizontal diameter of the tunnel bisected the height of the models. The forward end of the platform was streamlined to minimize the disturbance of air flow.

The 1-in. I.D. brass-tube miniature stacks were adjustable in height and were equipped for variable discharge of air up to 70 f.p.s. For the single unit, the "flue gas" was supplied through a 1-in. diam. rubber hose from a blower, driven by a variable-speed d.c. motor. The multi-unit stacks were fed through a large plenum chamber. The velocity of discharge was controlled by individual supply-line valves. A scale of 1 in. = 10 ft. was selected for convenience of size and ease of interpreting results. The six-unit model to this scale was in reasonable proportion to the diameter of the tunnel throat.

In other investigations of smoke dissipation, it has been found that wind velocity and wind direction are the only meteorological phenomena which appreciably affect the downwash of smoke. Consequently, such factors as humidity, air temperature and barometric pressure could be disregarded.

Turbulence was studied by means of threads. Taut, vertical strings were set up at 6-in. intervals in line with the stack in a plane parallel to the wind direction. White silk threads, 5 in. long, were used as streamers tied at one end to the vertical strings at 2-in. spacings. The length and spacing were selected after a considerable amount of experimental work to determine the most suitable type and arrangement of threads which

[1]The findings of this investigation reported here in brief were given in detail in a paper before the 1941 annual meeting of the A.S.M.E.

[2]Consolidated Gas, Electric Light and Power Co. of Baltimore.

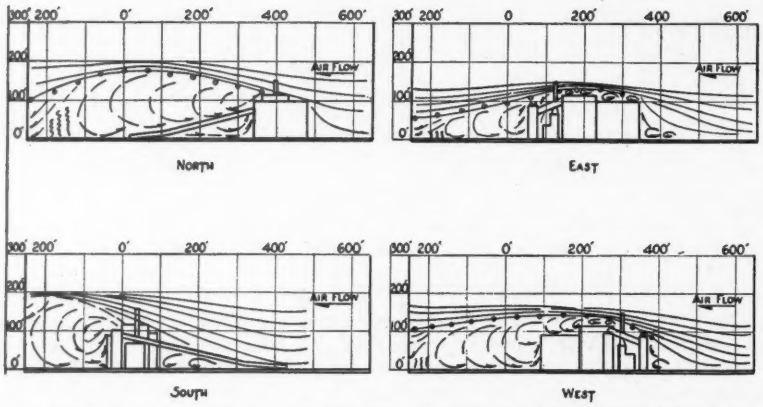


Fig. 1. Effect of wind direction on turbulence patterns; stack height 167 ft.; wind velocity 20 m.p.h.

would follow the path of the wind.

The area around the building was also explored by means of a fine silk thread on the end of an exploring rod. Flake mica (Christmas tree snow) was distributed at points around the building. The path of the particles of mica showed the regions of turbulence, the direction of flow, and the character of the vortexes. The turbulence areas were also investigated by means of droplets of titanium tetrachloride placed at spots around the model. On the basis of the fixed and exploratory indicators, charts were plotted to show the turbulence patterns produced in line with the stacks.

Figures 1 and 2 illustrate the effect of wind direction and wind velocity on the turbulence. The wind velocity affected the area of the turbulence zone to some extent, but did not in general affect the character of the turbulence pattern. The wind direction very markedly affected the area as well as the character of turbulence. The relative proportions of the building in the three planes is a vital factor. The surface of the single-unit building, exposed to north or south winds, is much greater than to east or west winds and, consequently, the turbulent zone extends higher with the north or south winds than with the east or west winds. Under the worst conditions, this turbulent zone extends as much as 70 ft. higher than the building. In the six-unit plant, the proportions of the building are reversed and, consequently, the turbulence patterns are quite different. With a 20 m.p.h. west wind, the six-unit model set up a turbulent zone equivalent to 120 ft. above the building.

A technique was developed for the discharge of a dense white smoke from the stacks. Ammonium chloride was used for this purpose because of its relatively low toxicity and corrosiveness, high degree of visibility, and freedom from fire or explosion hazards.

Results of Investigation

The effect of wind velocity was investigated in the range of 5 to 40 m.p.h. The tests brought out two conditions which may cause troublesome flue-gas concentration in the immediate vicinity of the plant, namely, extreme calm and moderately high wind velocities. In the almost complete absence of air movement, the stack-discharge gases rise more or less vertically from the stack and form a cloud over the building. This large mass of discharge gas tends to diffuse gradually downward.

With wind velocities from 5 to 10 m.p.h. and stack velocities of the order of 50 f.p.s., the discharge gases are carried in a gently curved arc upward clear of the surrounding property, with moderate stack heights. From a practical consideration, wind velocities in the neighborhood of 20 m.p.h. cause the most concern. Winds in this range occur with considerable frequency in the Baltimore area. With increasing velocity, the path of the smoke is carried lower. However, the rate of dissipation of smoke increases in proportion to the wind velocity, according to the investigation of Pearson, Nonhebel, and Ulander.

Our own observations show that, at high winds, in the neighborhood of 30 to 40 m.p.h., the downwash becomes very pronounced, but that the smoke is rapidly diluted. Although these higher velocities are relatively infrequent, and the rate of smoke dissipation is also in our favor, we believe that with the stack heights under consideration, there will be some annoyance from smoke when these higher wind velocities do occur.

The seriousness of the downdraft of smoke is very markedly affected by the wind direction. With the single unit, the north and south directions present a large area of building surface to the wind and create a particularly serious downdraft problem. With a south southeast wind, there exist the combined effects of the large southern exposure of the building and the complicated turbulence patterns created by the partial exposure of the stack-and-breeching structure to the wind. This tends to cause a downwash around the induced-draft-fan structure.

With the three-unit and six-unit models, cumulative disturbances are set up when the wind is blowing directly in line with the stacks. The smoke is brought lower and lower with each successive stack. With a south southeast wind, there is also a troublesome condition with the multi-unit models. The successive disturbances of the stacks and the disturbance of the building itself combine to create a serious downdraft.

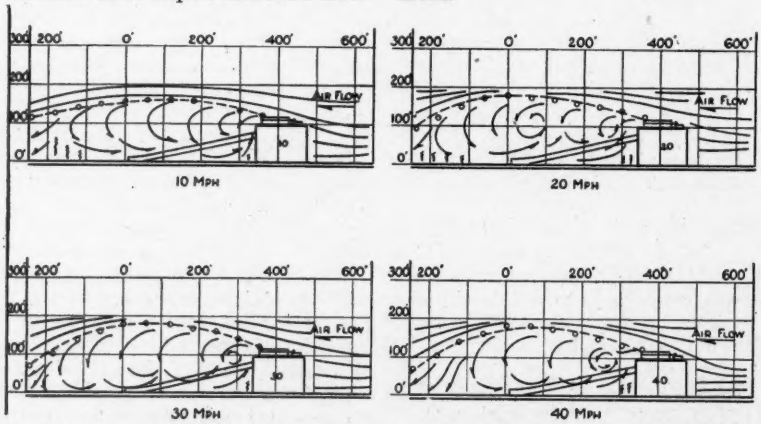


Fig. 2. Effect of wind velocity on turbulence patterns; stack height 127 ft.; north wind

The path of the smoke as it emerges into the atmosphere is determined by both stack velocity and wind velocity. However, it should be pointed out that, at equal stack velocities and wind velocities, the smoke does not emerge at a 45-deg. angle, as might be anticipated from a simple application of resultant forces. The problem is much more complicated.

Under average weather conditions, high flue-gas velocity is decidedly beneficial in carrying the smoke upward. A small diameter stack creates less disturbance and high velocity tends to carry the smoke above the disturbed area. Under the conditions of Fig. 2, an increase in stack velocity from 15 to 50 f.p.s. raises the upper limit of the smoke path about 50 ft. at the

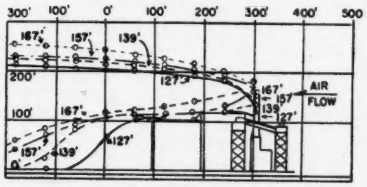


Fig. 3. Upper and lower outlines of smoke path; effect of stack height; 20 m.p.h. west wind; stack velocity, 50 f.p.s.

rear of the building. At wind velocities of the order of 30 to 40 m.p.h., the effect of stack velocity is less pronounced. With wind velocities of approximately 20 m.p.h. and with low stack velocity, there is a very pronounced downdraft of smoke immediately along the downwind side of the stack.

As would be expected, the seriousness of the downwash of gas decreases with increased stack height. With a 127-ft. stack elevation, which is approximately equal in height to the boiler room monitor, the lower portion of the smoke path sweeps over the model roof or swirls over nearby ground under a wide range of wind conditions. With a 139-ft. stack, the smoke path is approximately the same, but the concentration appears to be somewhat less dense near the ground. With a 147-ft. stack, the smoke path is raised somewhat, but continues to swirl to the ground. At 157 ft., the downwash is still pronounced, even at a 10-m.p.h. wind velocity in some directions. Consequently, at this stack height smoke annoyance would be anticipated on a large number of days each year. At 167 ft., downwash is present within limited angles of wind direction at 20 m.p.h., and quite general at 30 m.p.h. It is the authors' opinion that this is the minimum height at which the smoke downwash would not be entirely excessive.

Even at the maximum elevation of 175 ft., set for this group of experiments, some smoke is carried downward close to the base of the model with unfavorable wind directions at the higher wind velocities.

Special Structural Treatments

No appreciable improvement could be obtained by variation in roof design within practical limitations. Several types of monitor roofs, flat roofs, and sloping roofs, all with the same maximum elevation, were studied. There was not sufficient difference in the smoke dispersion for this to be a deciding factor in the selection of the alternate roof plans.

Since the flow of smoke was not entirely satisfactory within the height limitations set for these experiments, considerable efforts were made to test all possible devices that might improve discharge conditions. A large number of stack nozzles, Venturi jets, external flat-disk shields, streamlined shields, and flat and spiral vanes were tested. These devices were designed in an attempt to increase the gas-discharge velocity, break up the disturbance created by the stack, create a natural updraft outside the stack, or interfere with the downdraft of smoke back of the stack. The constricting nozzles, which increased the stack velocity, definitely raised the smoke path, but there are limitations to the use of such devices on account of the energy losses. Several of the shields produced improvement with critical adjustments under specific wind velocities and directions. Under other conditions, however these devices not only failed to produce improvement but created new troubles.

Since it was necessary in this case to select a stack height consistent with requirements dictated by the proximity of the airport, and, at the same time, to insure reasonable freedom from a smoke

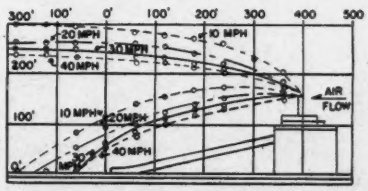


Fig. 4. Upper and lower outlines of smoke path; effect of wind velocity on smoke pattern; north wind; stack height 167 ft.; stack velocity, 50 f.p.s.

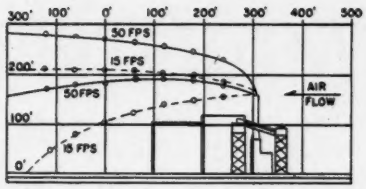


Fig. 5. Upper and lower outlines of smoke path; effect of stack velocity on smoke pattern; 10 m.p.h. west wind; stack height, 167 ft.

nuisance, a compromise had to be reached. From practical considerations, it was felt that the performance at wind velocities of approximately 20 m.p.h. should govern. The reason for this selection is the large number of days during which wind velocities in the neighborhood of 20 m.p.h. occur. Velocities in excess of 20 m.p.h. will definitely produce a greater degree of downdraft, but these stronger winds occur with diminishing frequency.

As would be expected, the amount of downdraft diminishes with increasing stack height. The model tests indicate that it is necessary to have a stack height of approximately 157 ft. above ground (elevation 167 ft. 1.31 times the height of the boiler-room monitor) to reduce smoke nuisance to reasonable limits with a 20 m.p.h. wind. Even at this stack height, there is noticeable downdraft of smoke around the model within limited angles of wind direction. Also at this height, some annoyance from SO_2 can be expected on the days when very high wind velocities occur.

OLD GENERATORS WORKING AGAIN

NOTED examples of veteran power machines aiding war production are ten 45-yr. old Westinghouse waterwheel generators recently mustered into active duty at the historic Edward Dean Adams station of the Niagara Falls Power Co. After 17 yr. as stand-by equipment, these generators are back at work helping to meet the needed power requirements of war production.

After a repair job with new parts, many such veteran machines are now doing more work than when they were new. The capacity of motors in service as long as 20 yr. has been increased as much as 50 per cent by equipping them with newly developed coils. This has been possible by changes in design and incorporating modern insulation materials.

MAINTENANCE and CORONA BLACKOUT

BY JOHN S. ASKEY
Generator Design Engineer
Westinghouse Elec. & Mfg. Co.
East Pittsburgh, Pa.

When we think of insulating covering for use on high voltage electrical conductors in generators and motors, we usually do not think of these conductors as having conducting properties. We picture the covering material largely in terms of its dielectric strength. Yet, as shown by Mr. Askey in this article a suitable conducting covering can play an important part in prolonging the life of the insulation. The conducting material is necessary to reduce the potential gradient along certain strategic portions of the windings and thereby eliminate damage due to corona. The Coronox method of protection has proved effective in many cases and it is applicable to old and new machines.

WHEN THE POTENTIAL GRADIENT of generating equipment exceeds 11,000 v. or lower, a discharge of electricity, called corona, appears on the windings unless suitable precautions are taken. Resulting from ionization of electrically overstressed gases, corona will attack all parts of the windings, within the slots around the coils in the area immediately beyond the ends of the slots, and in the air spaces between coil sides in the end windings. The presence of this activity in air-cooled machines can be found by either the odor of ozone, a grayish-white powder deposit on the windings after a period of time, pitting of the outer surface, or by a blue glow. In spite of the fact that the breakdown voltage in hydrogen is lower than in air, it can readily be seen that in the case of hydrogen-cooled machines, the corona problem is greatly lessened and is practically negligible because oxygen content is negligible.

Corona itself is not harmful, but its resulting by-products in air are powerful oxidizing agents and if combined with water vapor they form strong acids. The action of these by-products on organic varnish are responsible for the grayish-white powder which is produced by the slow oxidation of the varnish film covering the windings' outer surfaces and for the gradual weakening and decomposition of twines and other organic materials used for bracing and the end windings.

Fig. 1. After 10 yr. service the Aquadag-treated slot portion of this coil from a 13.8-kv. generator showed no deterioration

The main insulation of most high-voltage windings consists of mica, and this material is unaffected by corona attack. However, since certain organic structural materials are present, it is highly desirable to protect the entire winding from corona attack.

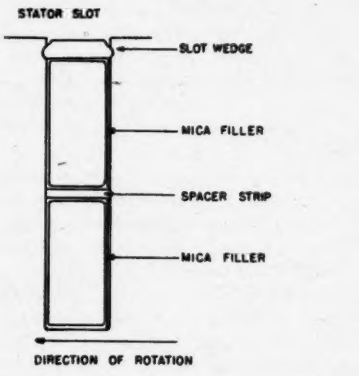
In years past the slot portion was most vulnerable. Protective paper fillers used in this location received corona's needlelike bombardment which in the early stages of attack pitted the paper. Eventually the paper was eaten away entirely, leaving the coils loose in the slots. Modern practice overcomes this weakness by encasing the mica insulated coil in a heavy armor consisting of a specially treated fiber-glass tape. Such coils are wound directly into the slots without any organic liners. Any tightening necessary is done by driving hard plate mica fillers along one side only as shown in Fig. 2.

The mica filler is best located with respect to rotation, retarding any tendency of the filler to flake out because of air currents. The circulation of the air in the unit actually blows against the face of the filler and not across its exposed edges as would be the case if the filler were located in the other side of the slot.

The driver or tool used to place the mica is also shown in Fig. 2. Note the offset edges. In the first stage of the driving operation they serve as guides and in the final placement of the filler, the longer edge is used on top of the filler with the short edge being out of the way. This puts the filler into its exact position without damaging the coil. The cut out sections

of the tool are merely provided for lightness and serve as means of handling the device.

Another main reason for the filler being used on one side only is that since the slot portions are protected with a conducting treatment (Aquadag or equivalent) against corona attack it is necessary that this treatment have good contact with the stator core. This point is of vital importance to operators who perform their own maintenance work without supervision by a representative of the coil manufacturer. The case to guard against is where an old, high voltage machine is being repaired. When a few (partial set) modern coils are installed in such a unit, the original coils not replaced will probably show that they were wound with fishpaper liners or cells between them and the core.



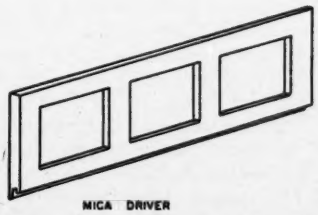


Fig. 2. When generator coils are wound directly into slots without organic liners, necessary tightening is done by driving a hard mica filler (b) along one side only

Evidence of corona attack upon coils and liners removed is almost certain, and usually great care is taken to install new cells with any new coils. This is incorrect and very dangerous, since the new coils are only effective if their slot portions are in contact with the core. Operation of coils, shielded for corona elimination, wound into fishpaper cells will result in corona so severe that the cells will be completely destroyed in a few months and the inorganic armor badly damaged.

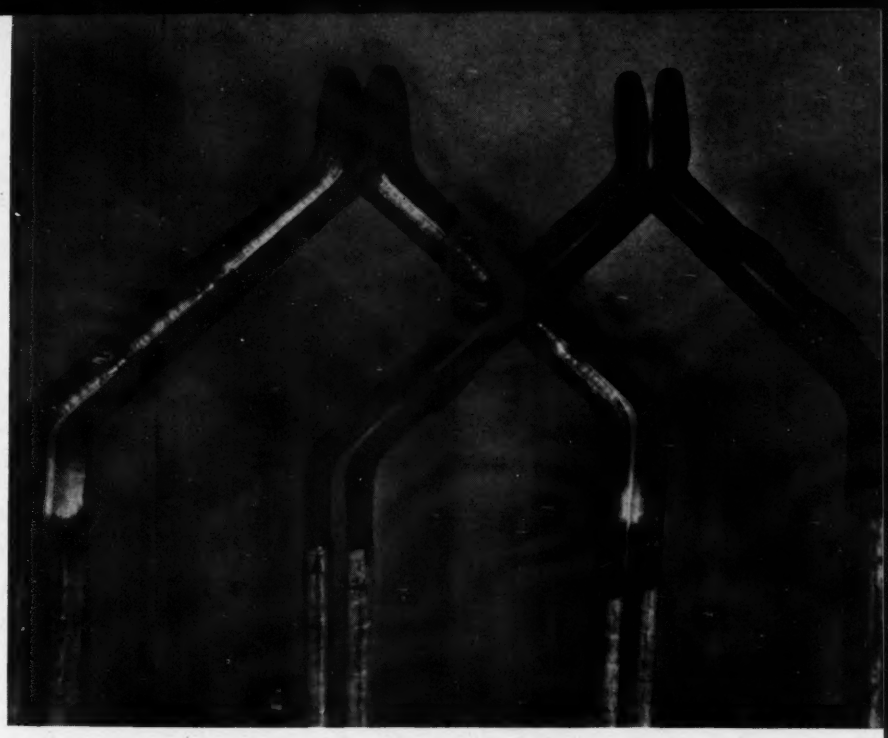


Fig. 4. Two pairs of coils with 25-kv. impressed between them. One pair has standard insulation and has violent corona. The other pair are Coronox-treated and are a blackout

Until 2 yr. ago the outer coil armor was asbestos instead of fiberglass. In addition to destruction of the liners, when shielded coils have been wound into them, corona attack has been sufficiently severe to partially destroy the asbestos armor. The result, of course, when material is destroyed, is coils that are loose in the slots. If permitted to operate in this condition, the coils will soon fail, with the penalty of an expensive repair and a long outage from service. When properly installed, the modern coil, with its asbestos or fiber-glass armor and its corona eliminating treatment in slot portion shows no deterioration after years of service. Figure 1 shows a slot portion of an asbestos armored coil after 10 yr. service without deterioration.

Corona immediately beyond the ends of the slots is usually evidenced by the discoloration of the surface varnish of the coils or by the tell-tale grayish-white powder. Results of corona attack can be readily seen in this locality. If the unit bears the characteristic marks here, corona attack has also usually taken place to varying degrees within the slots. Windings showing this attack can be identified as those manufactured prior to when this condition was corrected 12 yr. ago. The correction consists of extending the asbestos armor the full length of the straight portions, that is, not only throughout the slot portion but also for several inches beyond the end of the core, both at front and rear ends of the windings. The asbestos used was semi-conducting and by extending the semi-conducting slot portion treatment slightly beyond the ends of the core, the transition from the conducting surface within the slot to a fine insulating surface just beyond was made gradually. That is, the stress was not concentrated at the edge of the iron, where the non-uniform field in this position would produce a ring of corona around the coils. This simple and practical means of grading the voltage stress immediately beyond the ends of the core has been successful for the past 12 yr.

The last and most difficult place to eliminate corona is in the end turns of these high voltage windings. With much success in

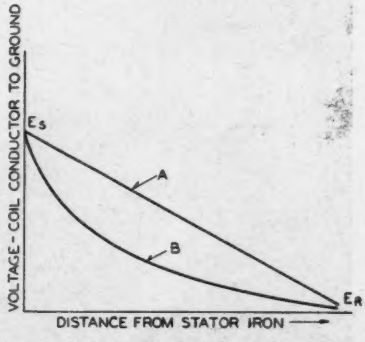


Fig. 3. Voltage distribution on the end turn of a coil for (a) ideal case where graded resistance is used on surface of end turn and (b) practical case where single resistance is used on surface of end turn

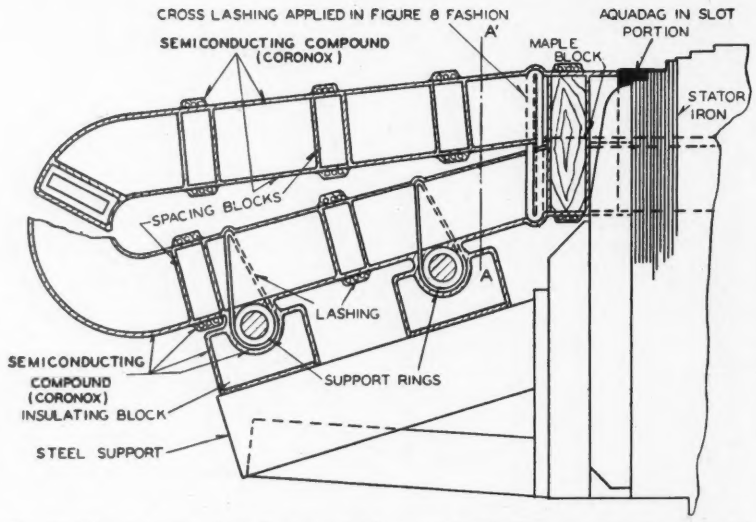


Fig. 5. Side view of end winding completely covered with Coronox, note also a special lashing applied in figure eight fashioned between the top and botton coil in a slot

the use of conducting material in the slot portion, why not continue their use in the end turns? Of necessity, the conducting materials used in the slots have a relatively low surface resistivity and produce a low resistance path to ground. If these materials were used upon the end turns they would in effect bring the entire surface of the end windings close to ground potential. This is a hazardous procedure not recommended because of the shape of the end winding. With its bends and joints, the end turns cannot be insulated as effectively as can the slot portions. If the end windings were not completely coated, then the ring of corona would appear where the treatment stopped. The answer to this complex problem of long standing has finally been found.

Corona elimination in the end windings can most economically and effectively be accomplished by grading the resistance of the insulation from the low value used in the slot to a suitable higher value in the end turns. The object is a uniform decrease in voltage. Figure 3 shows the relation of Curve (a), an ideal case for graded resistance, to Curve (c) for a practical case in which a single resistance covers the entire end winding. Commercially, uniform grading is not easy to obtain. A single material of proper resistance can reduce the voltage stress throughout the end turns sufficiently to completely eliminate corona at voltages well above present operating voltages. As a rule, operating voltages do not exceed 13.8 kv. with a plus or minus variance of 5 per cent. The conducting material which achieves this purpose is Coronox which has been considerably improved since its introduction in 1934. The effectiveness of the Coronox treatment is shown on Fig. 4. The pair of coils with heavy corona are those insulated in the usual manner, while the pair in total darkness, free from corona, are Coronox treated. The voltage in each case was 25,000 v., applied to one coil, the other coil being connected to ground.

This material lends itself well to commercial applications, particularly in new equipment. Machines totalling well over one million kv-a. have been successfully treated and tested. Of this total, 50 per cent are in service, the remainder being in process of assembly or installation. On new equipment the end turn of each and every coil is treated all over with Coronox of the proper value of resistivity. This value is predetermined from the calculated physical dimensions of the coil in conjunction with the known electrical characteristics of the particular insulation being treated. Sketches in Figs. 5 and 6 illustrate the plan of coverage and arrangement of bracing. Special emphasis is placed on the effectiveness of the lashing, in a figure eight manner, applied several inches beyond the ends of the core. The use of this band reduces the voltage stress between layers. This application is shown in Figs. 6 and 7.

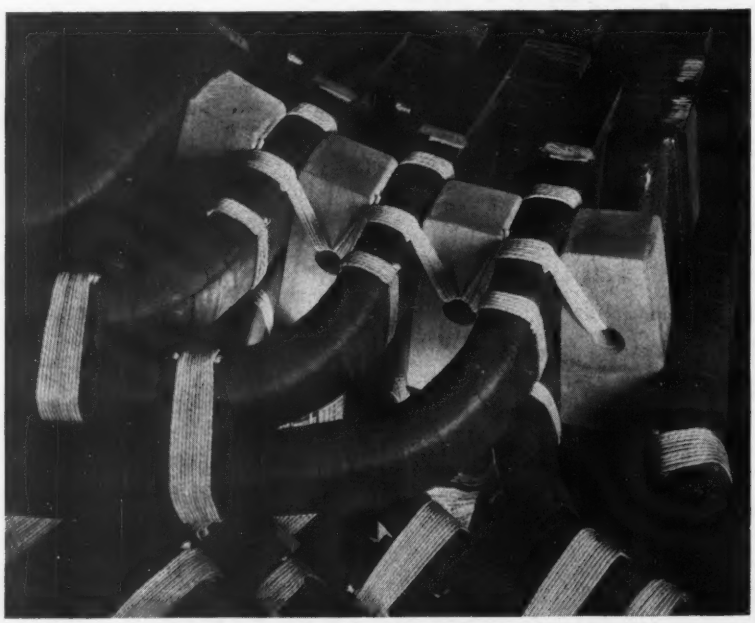


Fig. 6. Closeup of bracing and cross-lashing of Coronox treatment

The necessity of proper materials and their correct application cannot be too highly stressed. In the field, repairs or modernization can be effected with Coronox application only when certain difficulties are overcome. First, such an operation usually means removal of the rotor to gain access to the stator winding. The winding must be clean and free from any oil or dirt before it can be Coronox treated. This fact applies not only to Coronox which is applied as a liquid, but also to any insulating varnish or compound. If this "cleanliness" rule is not

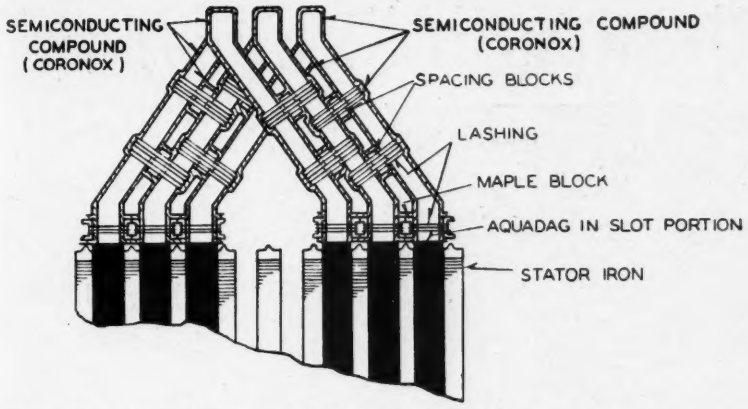


Fig. 7. View of end winding coated with conducting compound as seen from stator bore

obeyed before any retreatment of the windings, inadequate bonding results and corona activity will probably be greater than before. Third, to hold dismantling to a minimum, the voltage is graded off in the first few inches of the end turns beyond the end of the straight parts extending from the core. This means the removal of existing bracing material in this area so that this portion of the end turns may be thoroughly covered.

In view of the problems enumerated in the preceding paragraph, it is evident that consideration of such an extensive outage usually amounting to upwards of 3 wk. should only be given if warranted by damage already done by corona. This consideration should be the result of a thorough inspection of the winding by the operator and the manufacturer before any cleaning has been attempted.

As stated earlier, mica is unaffected by corona, and, therefore, the necessity of a major outage is unlikely. This is because the organic materials, which are subject to damage, can usually be replaced or adjusted to satisfaction without the necessity of a complete Coronox treatment.

Where examination shows that the extent of corona damage over a period of from 10 to 20 yr. of operation consists of nothing greater than oxidation of the surface varnish film, or a few isolated pitted areas, corrective steps should only include cleaning, replacement of any deteriorated lashing, followed by sprayed coats of a synthetic base pigmented compound which has been found superior to other materials used for the purpose of retarding the oxidizing action of corona by-products.

Data obtained on the effect of Coronox treatment of windings upon the insulation resistance of such windings indicate that lower values of insulation resistance can be expected from Coronox treated windings. This is especially true if the dielectric absorption (insulation resistance as a function of time) is studied. The effect of Coronox on dielectric absorption is illustrated in Fig. 8. Such lower values are caused by the leakage over the end winding provided by the Coronox. Measured values of power factor of the insulation will be comparatively higher than on similar untreated units. When interpreting insulation data on Coronox treated windings, lower insulation resistance, altered dielectric absorption and slightly higher power factor must be expected. They must be recognized as only a skin-deep effect, and have no significance in regard to the life or reliability of the insulation.

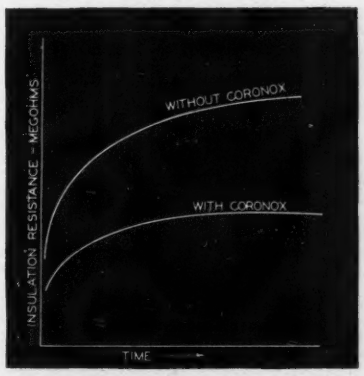


Fig. 8. Effect of treatment on insulation resistance-time relationship in completely wound machine

A review of the record of machines over the past 25 yr. built by the manufacturer with whom the author is associated does not show a single service outage which was due to corona attacks upon the main insulation. There have been cases, however, where failure resulted from corona discharge across comparatively small air gaps in the end winding, particularly between main phase rings or from a phase ring to ground. In these cases, such parts were insulated with organic materials only.

In view of service records, the presence of corona in existing machines which are mica insulated is not considered any breakdown hazard by the manufacturer. By eliminating corona from these units, either upon new machines being built or by adjustments to those in service to prevent deterioration of coil surface and retain the appearance of the insulation, the manufacturer has achieved an advancement in the art desired for many years by the electrical industry.

PROTECTIVE LIGHTING TO FOIL SABOTEURS

RECENTLY described by O. P. Cleaver, Westinghouse lighting engineer, at a meeting of the American Society of Safety Engineers, was a new type glare barrage using high-powered spotlights to blind would-be saboteurs as they approach restricted zones around war plants.

Already in use at several large eastern war plants, the new system employs special beacons developed by Westinghouse engineers, making it possible to keep guards and buildings in comparative darkness while the areas through which saboteurs would have to pass are brilliantly lighted. Beams are turned outward to direct a blinding glare in the direction of the intruders instead of playing the lights on the buildings. Thus, guards patrolling in the shadows command a view of several hundred yards somewhat in the manner that a night driver sees all objects on the road ahead of him while a pedestrian can see only the confusing glare of his headlights.

Similar to lights used in the lighthouse beacons which protect coastal shipping, the barrage unit is equipped with a high-powered lens constructed to project a flat, fan-shaped beam of light. Batteries of these lamps are mounted on posts several feet away from the buildings to be protected. In ordinary protective systems where lights are used to floodlight buildings, intruders often may come within 100 ft. of the restricted area in the safety of relative darkness.

Twenty Million Volt "Rheotron"

Fig. 1. The new 20 million volt rheotron with Dr. Donald W. Kerst, its originator, in the foreground and Dr. E. E. Charlton, head of the X-ray section of the General Electric Research Laboratory, in the background

DURING the past several years a number of new members of the famous "tron" family have made their appearance in the world. The most notable, perhaps, was the Cyclotron developed by Professor E. O. Lawrence, which is a device for accelerating positive ions to extremely high speeds and thus, endowing them with very high energies. These high energy ions are used to bombard various substances in atomic disintegration experiments. Because of this, the cyclotron has popularly become known as an atom smasher.

Recently, a new device has appeared somewhat similar to the cyclotron in that it is also used to impart high energies to electrified particles, but quite different in principle to the cyclotron and is used to accelerate electrons rather than positive ions. The cyclotron is incapable of accelerating electrons.

This new device has been called by its originator the "Rheotron". A large and powerful unit built recently at the General Electric Research Laboratory in Schenectady opens up a new field for scientific exploration by the production of an electron stream far more penetrating than any ever achieved before.

This achievement is largely due to the work of Dr. Donald W. Kerst, and is based on an extension of his preliminary studies at the University of Illinois, and on a small machine which he built there. By means of the new unit, electrons are accelerated to the highest speed ever produced by a man-made apparatus. It gives them energy corresponding to 20,000,000 v. and also produces X-rays of this power.

Dr. Kerst, a 30-yr.-old physicist now in the laboratory on leave from the University of Illinois faculty, built the new rheotron with the aid of G.E. engineers and scientists. Dr. Kerst is taking the new machine already built to the campus at Urbana for experimental work there.

So promising have been the results obtained with the rheotron, that the laboratory has already started work on a larger one to cost more than a quarter of a million dollars and designed to whirl electrons to an energy of 100,000,000 v.

Though much more powerful than the towering equipments previously used to accelerate electrons to very high speed, the rheotron is a comparatively small device. The magnet of the present machine is only 5 ft. long, 3 ft. high, and 2 ft. wide. It does for negative electrons what the cyclotron does for positive ions, but does it in a different way, and, for a given voltage, is much smaller.

It consists essentially of a doughnut-shaped glass vacuum tube, between the poles of a large electromagnet. Electrons from a hot filament within are whirled around the tube and steadily accelerated by electromagnetic forces until they attain a speed closely approaching that of light.

In commenting on this development, Dr. W. D. Coolidge, director of the G.E. Laboratory, said that the rheotron provides an important new tool for fundamental research.

"Hitherto, experiments with high velocity electron beams have not kept pace with experiments done with positive ions from the cyclotron," he explained. "The cyclotron is incapable of accelerating electrons, and previous devices able to do so have seemed to reach a practical limit at something like half the voltage of the present accelerator.

"The rheotron seems to have no such limit and its effective voltage can apparantly be increased indefinitely. It works not by applying the entire voltage at once but by building up the speed steadily throughout all revolutions. As a result electrons have already been given sufficient velocity to penetrate an inch of aluminum."

The present machine weighs

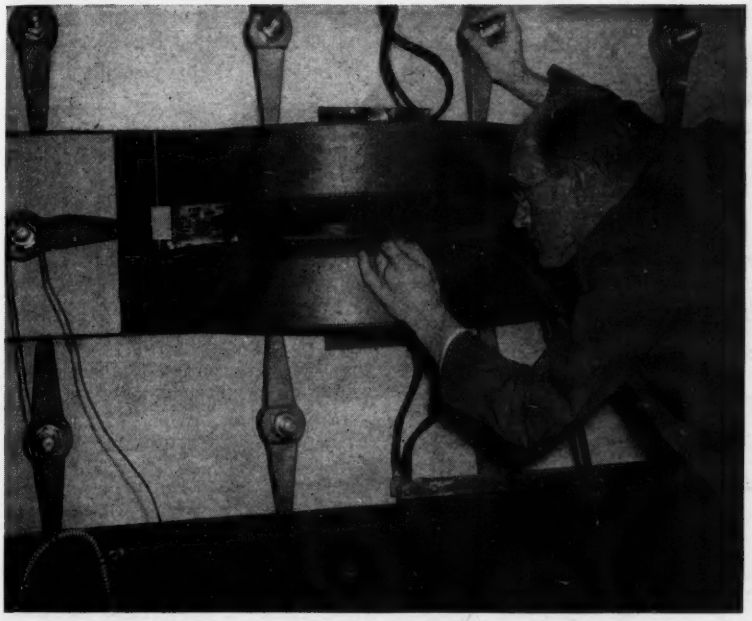


Fig. 2. A close-up of the rheotron with W. F. Westendorp of the G.E. Research Laboratory making an adjustment

about 4 tons. The pole faces of the two electromagnets which sandwich the doughnut-shaped glass vacuum tube are 19 in. in diameter. The tube has an outside diameter of 19 in., an inside one of 11 in. and is about 2 in. in thickness.

Since it is designed for use on alternating current, the magnet assembly of the rheotron is of laminated silicon steel, instead of solid iron as in the cyclotron. Instead of circling the magnetic field by following a coil of wire, as in a high-voltage transformer, the electrons whirl around inside the evacuated doughnut-like tube.

Magnetically guided, each electron travels along a circular path for about 400,000 revolutions, receiving as much as 70-v. push each time around, and traveling some 200 mi. in a small fraction of a second to gain a speed within a tenth of 1 per cent of that of light. By causing these electrons to collide with a metal target, X-radiation equal in intensity, as determined by ionizing power, to the gamma radiation in a corresponding beam from more than 1000 gr. of radium, more than the world's existing supply, can be produced by the machine.

Dr. Kerst, the designer of the rheotron, was born in Galena, Ill., and later lived in Wauwatosa, Wis., where he became interested in science as a boy in helping a neighbor build an amateur radio station. He received an A. B. degree in 1934 and a Ph.D. degree in 1937 from the University of Wisconsin, where he was a member of Phi Beta Kappa, Sigma Xi, and Gamma Alpha.

He did research work at Wisconsin with Dr. Raymond Herb and Dr. David B. Parkinson with pressure electrostatic machines which attracted attention in scientific circles and led several institutions to construct them for nuclear research.

Dr. Kerst then worked for a year on X-ray tubes in the laboratory of the General Electric X-Ray Corp. in Chicago and while there became interested in the principles of the rheotron. He carried his studies to a complete development of the theory at the University of Illinois and built there the first successful machine of this type—a table-top size, capable of 2,300,000 v., which has been described in a paper read before the American Physical Society. Last year Dr. Kerst obtained a leave of absence from the university to permit him to build a larger machine with the assistance of the General Electric Research Laboratory. The present machine is the result.

The word "rheotron" is a combination of the Greek words rheo, meaning flow or flux, and tron, meaning agency for producing.

VISITORS NOT BARRED AT GRAND COULEE

VISITORS have all the rights and privileges at Grand Coulee Dam they had before the war started, but the highway over the crest of the 10½ million cubic yard concrete structure remains closed to traffic. Only government cars on official business are permitted to use the thoroughfare and then only after one of the Bureau of Reclamation's 58 guards has made a careful check of the driver's identity. Octagonal-shaped guard houses and high wire fences have been placed at strategic points on the project to safeguard it. Rumors circulating through the Pacific Northwest and other parts of the country that sight-seers can no longer see the dam at close hand are false, the Bureau said. All facilities available in years past remain open.

Inspection of PIPING SUPPORTS

Periodic checking of the fixtures supporting piping and its fittings is a responsibility of the operating staff. In order that this may be done systematically, a form has been devised which is based on piping code requirements, and an outline of procedure is indicated

SO GRADUALLY does the service of a piping system take its toll out of the material and equipment that in many cases costly damage has been done before defective conditions are detected. Twenty or more years of service for piping is commonly expected. Valves and fittings usually demand periodic attention because of worn parts or leaks, but the piping itself is too frequently expected, without inspection or repair, to have a life almost equal to the building structure in which it is located.

While there are many other indications or symptoms of piping system defects, sagging and misalinement though easily detected and readily remedied are too frequently tolerated even though known to put undue strain on parts of the system. In the history of the average power plant, the newly completed plant is turned over to the operating staff in an acceptable working condition with the expectation that some unforeseen conditions of comparatively minor importance may develop which will need correction during the first year or so of operation. This applies especially to the piping system since the majority of the fabrication work must be done in the plant, often before the structural work of the building has been completed and the supporting members have attained their exact permanent set.

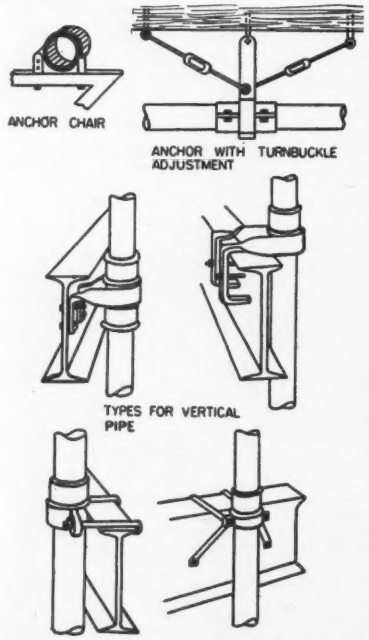


Fig. 1. Types of anchors commonly used to hold power plant piping

Under these conditions a certain amount of flexibility must be provided in the piping system not only to care for deflections in structural members due to varying strains as the building is being erected and loaded with power machinery but also for expansion and contraction due to temperature changes. This process of seasoning will require a year or more before all adjustments can be worked out satisfactorily.

During this period pipe anchors must be examined frequently for movement, cracking of parts, inability to hold pipe or any other failure to perform their functions. Hangers, brackets, standards, braces and nearly all other supports are provided with means for adjusting the pipe level and alinement, and this work must be done during the initial or seasoning period of operation. What is said of the new plant is equally true of sections of an old plant where new equipment and piping service have been added.

If the piping system has been carefully maintained during this initial operating period, experience has shown that few adjustments will need to be made in the supporting fixtures until structural weaknesses begin to appear in the building itself such as crumbling footings, rusting columns, sinking floors.

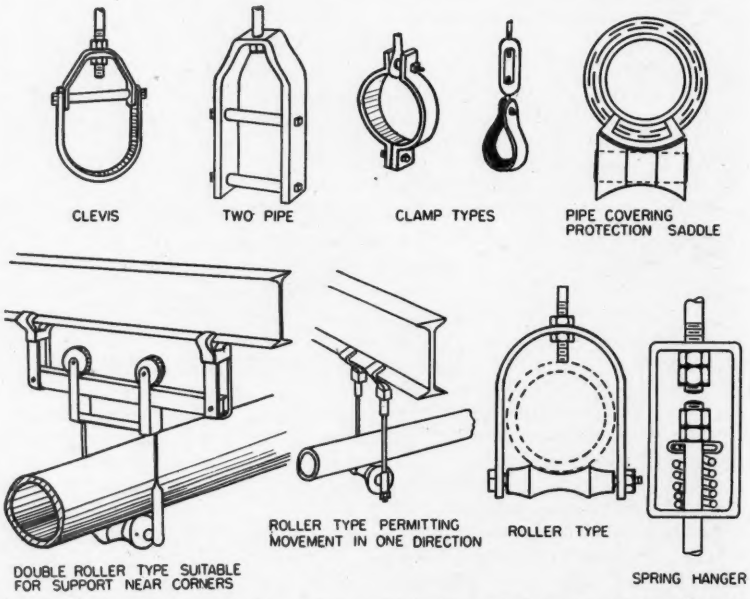


Fig. 2. The function of a pipe hanger is to maintain the particular section of the piping to which it is applied at the proper level by supporting it from above. Here are a few of the numerous designs employed

Inspection Procedure

From the time fundamental structural repairs to the building housing the piping begin to be required, piping inspection and maintenance work should be carried out more intensively if satisfactory service is to be had.

Inspection of a piping system for alinement starts with the an-

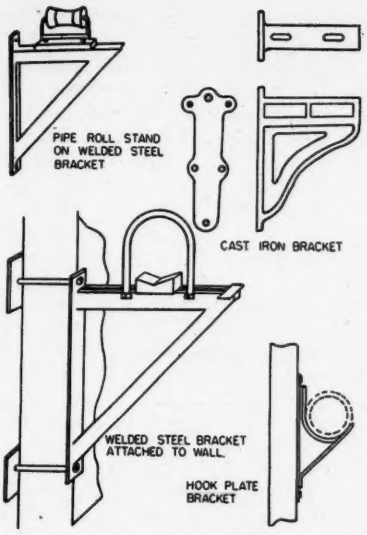


Fig. 3. Brackets and hook plates are used to support piping along walls or columns

chors which must be structurally sound, correctly located and at the proper levels. Proceeding from these points, levels should be taken at hangers and other supports to see that the piping conforms with the design requirements. This determination of levels is commonly done with a surveyor's transit or level instrument, but where such is not available a leveling water hose can readily be made and used with remarkable accuracy. As the work of taking levels proceeds, extensive notes should be made of the physical condition of piping supports and any deviations in dimensions and locations from the piping system drawings for the plant.

The maintenance man faced with the problem of inspecting and repairing a piping system that has been in service beyond the initial period can safely assume that the system design and fabrication was carried out in accordance with the power piping code and that any conditions contrary to the code or deviating from the piping system design are the result of service conditions and need investigating to determine whether or not adjustments, repairs or replacements are necessary.

Code Requirements

In regard to hangers, supports and anchors, the code states: "Piping and equipment shall be supported in a thoroughly substantial and workmanlike manner, rigid enough to prevent excessive vibration and anchored sufficiently to prevent undue strains on boilers and equipment served. Hangers, supports and anchors shall be made of durable materials. In tunnels and buildings of permanent fireproof construction, these materials shall be non-combustible. In buildings of non-fireproof construction, piping must be supported on or hung from wood structures provided that all piping used for conveying fluid at temperatures above 230 deg. F. shall be spaced or insulated from such wooden members to prevent dangerous heating.

"Hangers and supports shall be so installed as not to interfere with the free expansion and contraction of the piping between anchors. All piping shall be carried on adjustable hangers or properly leveled supports, and suitable springs, sway bracing, vibration dampeners, etc., shall be provided where necessary."

Use of Check Sheet

With this part of the code as a guide, the accompanying check sheet has been worked out as a convenience for the inspector in making his report on the condition of the fixtures supporting the piping system.

While this form is almost self-explanatory a few words on how it may be used may be helpful. The general information asked for at the head of the form identifies the fixture being inspected and makes the ordering of a new fixture or part convenient.

In the tabular section, the idea is to report all the unsatisfactory conditions or indications of possible defects in the fixture under observation. The item support, for example, refers to the bolts, rods, screws, clamps and other special devices for attaching the fixture to the beam, column, wall or pedestal and it would be desirable to report defects in those structural elements themselves, particularly if those defects are liable to cause piping misalinement.

Swinging or vibrating of sections of piping are undesirable con-

PIPE INSPECTION CHECK SHEET FOR SUPPORTING FIXTURES

PIPE LINE	SERVICE & LOCATION
	SIZE PRESSURE TEMPERATURE
FITTINGS	THREADED ☐ FLANGED ☐ WELDED ☐
SUPPORT DEVICE INSPECTED:	
	ANCHOR ☐ BRACKET ☐ HANGER ☐
	SUPPORT ☐ _____ ☐
	LOCATION
	DIMENSIONS
	TYPE CAT. NO.
	MANUFACTURER

CONDITIONS TO BE SATISFIED	GOOD	POOR	REMARKS
SUPPORT			
RIGIDITY			
STRAINS			
MATERIALS			
EXPANSION			
ADJUSTMENTS			
LEVEL			
ELEMENTARY PARTS			
PROTECTIVE COATING			

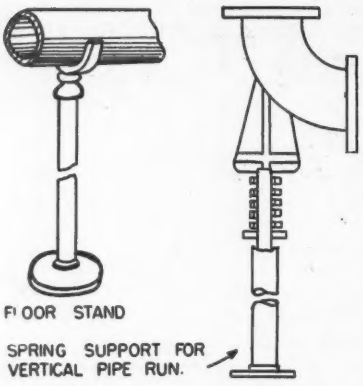


Fig. 4. Pipe stands are employed where it is desirable to support the piping from the floor

ditions that need to be held to a minimum by proper design of the system and careful location of properly chosen supporting fixtures. Piping that is too rigid exerts tremendous strains not only on the supporting fixtures but also on the piping and fittings. A reasonable amount of flexibility is necessary, but rhythmic swinging and vibration are liable to cause crystallization and cracking. Supporting fixtures properly chosen and spaced will usually stop this undesirable movement.

Strains beyond the capacity of the fixture will in time, if not immediately after the equipment is put into service, cause breaking of parts such as bolts and braces. These cracks and breaks are not always easy to locate as they may be hidden within the parts of the fixture or covered with insulation, paint or dirt. A ringing blow with a hammer will detect many such defects. Undue strains may also be the cause of movement between parts that are supposed to be rigidly fastened together. One symptom of this is the cracking of paint at such joints or the evidence of disturbance in the accumulation of dirt on the fixture. When in doubt, dismantle the fixture and examine each part separately.

Evidence that the material chosen for the fixture fully meets the conditions of service can usually be had only after it has been in use a number of years. Occasionally a poorly selected design or one too weak for the service will result in early failure, but the wear of moving parts or deterioration due to corrosion should be so slight as to be non-detectable for many years, otherwise the material is not suited to the conditions of service.

Piping submitted to temperature changes needs room to expand and contract. To insure proper service, it behooves the maintenance men to make regular inspections of all pipe anchors to make certain that they are properly performing their function of rigidly holding the pipe at the point of application. These fixtures are subjected to reversing strains and, if the attachment to the pipe is not solid, the forward and backward movement is liable to cause erosion. Anchors must be sufficiently solid to overcome the friction of operating expansion joints or to resist the spring force of expansion loops where they are employed. When it is realized that 100 ft. of steel pipe will expand 3.98 in. while being raised in temperature from 80 to 540 deg. F., it is at once apparent that expansion must not only be provided for but that certain definite points in the system must be kept permanently stationary, and it is the duty of the inspector to make certain that the pipe anchors are performing this function.

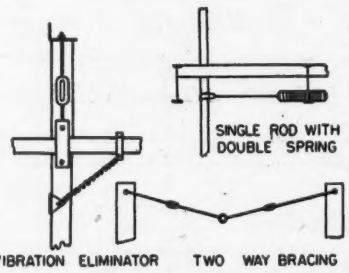


Fig. 5. Sway braces and vibration eliminators employ springs to absorb these undesirable pipe movements

Pipe hangers, supports and some designs of anchors are provided with means for adjusting the exact location of the pipe. These must be used with discretion as disturbing the adjustment in one fixture may require compensating adjustments in others in order to obtain proper alinement. The inspector will find the adjusting rods, turnbuckles and threads are occasional sources of weakness, as workmen are prone to put too great strains on the adjusting devices. So extra care in inspecting these parts is advisable.

Manufacturers have developed hangers of the type that compensate for expansion and contraction employing springs or counterweights. These fixtures have moving parts with bearings that need careful inspection at regular intervals. Roller supports that permit lengthwise movement of the pipe in a horizontal direction should be examined to see that they actually roll.

Horizontal pipe lines must be supported at intervals to prevent undue sagging or to maintain a proper degree of pitch to insure drainage of condensate. The allowable distance between these supports depends upon the size and weight of the pipe and the weight of the fluid in the pipe, the insulation, the valves and pipe fittings which may be included in the line. Steam pipes, installed without downward pitch, form condensate pockets in each span, so it is necessary to maintain the proper level, usually a pitch of 1 in. in 25 ft. at hangers, supports and anchors to prevent this undesirable condition. While mathematical formulas, tables and charts are available for calculating the deflection between supports, the inspector may safely consider that the variation in level between two supports is satisfactory if the pipe at the forward support is lower than at any point in the preceding span. Where this cannot be the case, as at the beginning of risers, means for draining condensate must be provided. If sagging between supports causes pockets either the supports must be placed closer together or the pitch of the pipe run increased sufficiently to prevent the pockets.

Elementary parts are those individual material elements that go to make up the design of the fixture down to the screws, bolts, rods, clamps and other essential parts that have been used in the construction and installation of the fixture. The inspection job is not thoroughly done unless the condition of these parts has been investigated and reported upon.

Satisfactory service of piping supports demands that they be protected from the corrosive effects of the atmosphere surrounding them. This may be provided by hot dipped galvanizing, coating with weather-resisting paint or covering with other suitable coating. Coating of this sort, however, should not be applied until after the inspection job has been completed for it is difficult enough to detect worn parts, cracks and corroded surfaces without having to guess at the condition under a coat of paint.

With blank forms of this sort carefully filled out and checked for each pipe supporting fixture, the maintenance and repair men can be given detailed instructions regarding their part of the piping alinement work.

The PRACTICAL ENGINEER and ELECTRICIAN

RICHARD H. MORRIS, EDITOR

STICKING YOUR NECK OUT

"Your questions," writes a friend, "are too indefinite and do not always give sufficient information upon which to base a conclusive answer. I suppose they are doctored up with that in mind . . . but many of my acquaintances feel that an answer means sticking the 'neck out' too far for comfort so they just sit tight."

That, of course, is the refuge of the selfish and uncertain, the man unwilling to share with others what he knows for fear of being criticized for what he doesn't know. Fortunately for the progress of engineering such men are in the minority.

Engineering is about 90 per cent experience and 10 per cent theory. So-called "authorities" may agree on the basic theory involved in a given case but disagree violently on the proper practical application. And experts do disagree between themselves just as violently as do two firemen. The funny thing is that all parties may be right for there are too many factors which we have not yet learned to take into consideration and evaluate.

Recently I was talking to one of the leaders of a national group of engineers grappling with current operating problems, about the period around 1925. He said: "We've come a long ways since those days, yet we are just now finding out how little we really know and how much remains to be learned. I shudder when I look back at the things we used to do and I shudder today when I look up at a high temperature header and realize what implicit faith we place in limited experience and empirical rules to safely control these tremendous amounts of energy."

Every man is an expert within the limits of his experience and education, but the measure of an engineer is his ability to adapt past experience of his own and others to new conditions. This is required to a high degree in answering questions, for contrary to the opinion expressed in the first paragraph, the questions are not doctored beyond occasionally rewording to make the question clear. All the information we have is included.

We realize many of the questions are incomplete and that they cannot be answered fully without assuming certain data or conditions which are not given. This is always permissible. After all the question states a problem that is bothering some engineer. A definite answer is not nearly as important to him as is the method of approach.

Nor need the method of approach always be the same. We must assume that given the experience of several others, even though this experience be conflicting, he has the intelligence to select for his use the parts which seem to apply best to his conditions.

Questions can usually be worded to require specific answers. That type of question and answer is a catechism. It is not well adapted to practical engineering. We attempt to make the Q. & A. Department an Operating Forum or Round Table where the problem is stated and thrown open for the expression of opinions and for discussion.

Your neck may well be stepped on—that's the price one must pay for stepping out of the ranks to lead rather than to follow blindly.

Richard H. Morris

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A Section of Power Plant Engineering Devoted to
PLANT OPERATION AND MAINTENANCE

Technical Publishing Company
53 West Jackson Blvd., Chicago, Ill.

Forced Draft Requirements —Get Joe Steamed Up

By J. R. DARNELL

Taking a cue from two previously published articles, the author, a chemical and combustion engineer whose record includes field experience with the Bureau of Mines and industrial plants, questions the advisability of calculating air requirements and fan capacities by simple equations. In practice, from 10 to 25 per cent is added to calculated fan pressure and capacity as a factor of safety or uncertainty. These oversize fans lead to many operating control difficulties and also to the conclusion that when the author argues about the correct average figure as 7.50, 7.60 or 7.65, he is "quibbling." Quite aside from this, however, the author presents a great deal of information on combustion calculations. Because of length, the discussion is presented here as an article rather than in the Letters and Comments section

COMMENTS of W. S. Patterson in the June issue (p. 84), relative to the article How to Determine Forced Draft Air Requirements, by E. M. Sims, in the February issue (p. 94), revives certain thoughts which I had at the time I read the original article. This purports to show several empirical formulas by which the volume of air required for a forced draft fan may be determined.

One of the basic errors in the chain lies in the assumption that the figure of 7.65 lb. is the correct average value for the air required per 10,000 B.t.u. in the fuel, with no excess air. This figure is assumed to apply to firing with any kind of fuel, oil, hard and soft coal, or lignite. However, calculations for a large number of samples of various fuels have shown that the overall average may be nearer 7.5 lb. This will be shown subsequently.

An interesting observation of Mr. Sims' figures is that the apparent average of the nine examples which he gives should be 7.601 lb. instead of 7.65 lb., even assuming that the figures as given, varying from 7.50 to 7.66, are correct for each individual fuel. This error, of itself, might cause some further error in the calculation of a large volume of air for a large boiler.

Furthermore, the analyses of the various fuels shown by Mr. Sims total 100 per cent without any allowance for nitrogen. Of course, in most cases nitrogen values are in the order of one per cent so that this error, of itself, would be minor. However, even a number of minor errors, if they should be all in the same direction, might total an appreciable amount.

Nevertheless, it appears that the figures for pounds of air per 10,000 B.t.u. are in error, even assuming that the figures for pounds of air per pound of fuel are correct. For example, the table shows 6700 B.t.u. for North Dakota lignite with 5.0 lb. of air per lb. fuel, and 7.54 lb. air per 10,000 B.t.u. But 5.0 (10,000/6700) equals 7.46 lb. per 10,000 B.t.u.

Furthermore, if a complete calculation is made for the pounds of air per pound of fuel, it will be found that all of the values[1] must be revised. Approximate corrected figures based on the fuel analyses are given by Table I.

Although the revised figures in Table I are approximately correct for the particular analyses of samples of fuel, the kind of fuel if the excess air were as high as 60 per cent.

The chart at p. 108 of the February issue fails to take into consideration an important variable in boiler room operation, namely, exit gas temperature. Any correlation of excess air and efficiency must also consider exit gas temperatures.

Supposing a power plant engineer plans to install a forced draft fan for burning West Virginia coal at 85 per cent efficiency, with an exit gas temperature of 450 deg. F., and boiler room temperature of 70 deg. F. and produce 1000 b.hp. The first step is to find the per cent excess air if the coal analyses is known. Using the figures given by Mr. Sims for West Virginia coal[2] we find the air theoretically required per pound of coal by the formula:

Lb. of air at maximum CO_2
$=11.52C+34.56\,(H-O/8)+4.32\ S\ldots$ Eq. 1

Where C is the carbon, H the hydrogen, O the oxygen and S the sulphur in the coal all expressed as fractions i.e. per cent divided by 100. For the example of West Virginia coal, the weight of air per pound of coal at maximum CO_2 (assuming no carbon lost in the refuse), would be 11.15 lb. But this doesn't give the pounds of air which would actually be required in plant practice under the above conditions of efficiency.

Assuming there is 10 per cent carbon in the refuse and 5.27 per cent dry ash in the coal, then 1.00 — 0.10 equals 90 per cent ash in the refuse, and 1.00/0.90 equals 1.11 per cent refuse for each 1 per cent ash in the coal. With 5.27 per cent dry ash, 5.27×1.11 equals 5.85 per cent refuse, and the weight of carbon in the refuse as a fraction of a pound of dry coal is 0.0585 times 0.10 or 0.585 lb. carbon.

Since there is 3.1 per cent moisture in the coal as fired, there is 0.585 times 0.969 or 0.565 per cent of each pound of coal found in the ash pit. The amount of carbon actually burned per pound of

[1] Values for pounds of air per pound of fuel and pounds of air per 10,000 B.t.u. will be further reduced from those shown by Mr. Sims if the amount of carbon in the ash pit refuse is taken into consideration.

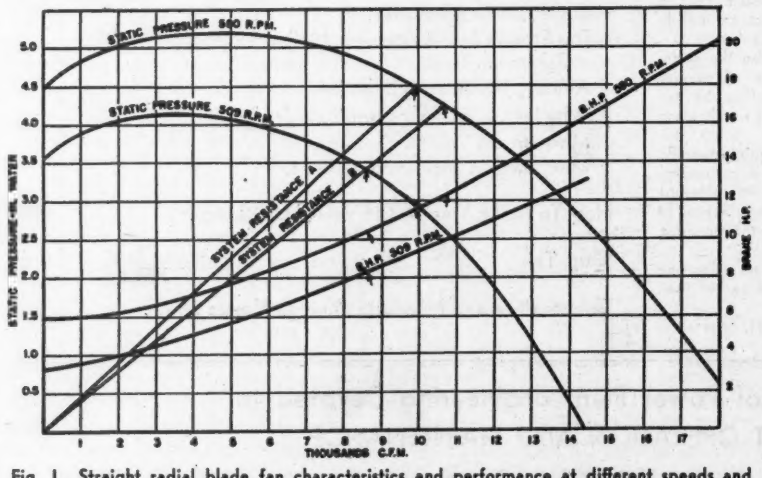


Fig. 1. Straight radial blade fan characteristics and performance at different speeds and system resistances. The system resistance for stoker firing is assumed as a straight line instead of a square root curve as in the case of other types of firing or for induced draft. Arrows indicate points referred to in the text

[2] C, 84.3; H, 4.7; O, 5.2; S, 0.7; ash, 5.1; (composition moisture included). Moisture, 3.1. B.t.u., 14,688.

Table I. Air requirements per pound of fuel and per 10,000 B.t.u.

	Lb. air per lb. fuel	B.t.u. per lb.	Lb. air per 10,000 B.t.u.
N.D. lignite	5.027	6700	7.503
Colo. lignite	7.401	9941	7.445
Ill. bituminous	8.349	10989	7.598
Ohio bituminous	9.625	12733	7.559
Pa. bituminous	10.203	13700	7.447
Pa. semi-bit.	10.705	14096	7.594
W. Va. semi-bit.	11.151	14688	7.597
Pa. anthracite	9.492	12472	7.611
Cal. crude oil	14.019	18565	7.552
		Av.	7.545

coal fired will be 0.843 minus 0.00565 or 0.83770 lb.

This will reduce the theoretical amount of air required per pound of coal to 11.08. The actual amount of air required can then be determined by calculating the amount of excess air used under the stipulated conditions of 85 per cent efficiency, 450 deg. F. exit gas temperature, and 70 deg. F. boiler room temperature.

But in order to do this, since we do not know the percentages of CO_2 in the flue gas, we must assume this value and then check our results by calculating a heat balance. The largest item of loss, of course, will be the dry gas loss. The maximum theoretical CO_2 will be:

Max. CO_2 in per cent

$$= \frac{20.9}{1 + \left(\frac{2.38\,(H - O/8)}{C + 0.375S}\right)} \quad \text{. . . Eq. 2}$$

$$= \frac{20.9}{1 + \left(\frac{2.38 \times (0.047 - 0.052/8)}{0.843 + (0.375 \times 0.007)}\right)}$$

$= 18.7$ per cent.

Assuming 15 per cent CO_2, the excess air will be:

$$= \frac{(18.7 - 15)\,0.791}{15.0\,(100 - 18.7)} = \frac{2.93}{12.2} \text{ or } 24 \text{ per cent excess air.}$$

Then, 1.24 times 11.08 equals 13.7 lb. air per lb. coal. The amount of gas per pound of coal will be found by adding to the weight of air per pound of coal fired, that per cent of 1 lb. of coal, which actually passes up the flue as gas. This is found by subtracting from 100 per cent the per cent of ash in the coal, plus the per cent of 1 lb. of coal found in the refuse.

In this case there is 5.27 plus 0.565 or 5.84 per cent left behind and 100 minus 5.84 equals 94.16 per cent of each pound of coal that is converted to gas. Then, 13.7 plus 0.9416 equals 14.64 lb. gas per lb. fuel.

In calculating a heat balance we find:

Dry gas loss

$= 14.64 \times 0.25 \times (450 - 70) = 1390$ B.t.u.

and 1390/14,688 equals 9.5 per cent dry gas loss. The constant 0.25 is the specific heat of flue gas in B.t.u. per lb. per deg. F.

Moisture and hydrogen loss is:

$9H\,(212 - 70) \times 970.4 + 0.46\,(450 - 212)$

$= 518$ B.t.u.

then

518/14,688 equal 3.53 per cent.

In the above 0.46 is the specific heat of superheated water vapor and 970.4 is the latent heat of steam at atmospheric pressure.

The loss due to moisture and hydrogen is calculated in one step if the ultimate analysis is really "ultimate" i.e., with the moisture divided into hydrogen and oxygen. Column A shows such an analysis while in column B the hydrogen is reduced by 1/9 and the oxygen by 8/9 of the moisture. The latter is, of course, included to total 100.

	A	B
C	84.3	84.30
H	4.7	4.36
O	5.2	2.44
S	0.7	0.70
Ash	5.1	5.10
Moisture	none	3.10
	100.0	100.00

When using the method of analysis shown by column A, the value of 9H in the formula for moisture and hydrogen loss includes the hydrogen in the fuel and the hydrogen equivalent of the moisture.

Ash pit loss

$$= \left(\frac{0.565 \times .0527}{1.0 - .00565}\right) \times 14{,}600$$

$= 44$ B.t.u.

and 44/14,688 equals 0.3 per cent

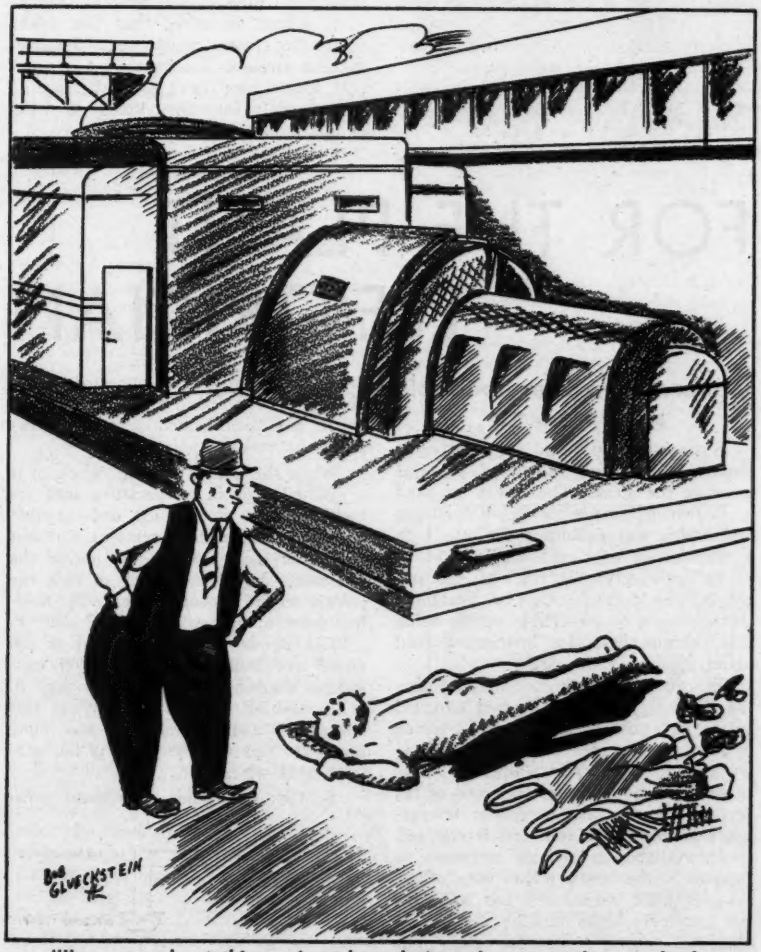
Summarizing we find,

Efficiency	85.0
Dry gas loss	9.5
M and H loss	3.5
Ash pit loss	0.3
Total	98.3

Thus we see that even with the exit gas temperature as low as 450 deg. F, the excess air as low as 24 per cent, and the carbon in the refuse as low as 10 per cent, that in our attempted balance we have only 1.7 per cent left for radiation and unaccounted for losses.

Certainly, the radiation loss will not be any less than this figure and probably will be at least 2.5 per cent, if not more. This means that either the excess air will have to be even lower or the flue gas temperature lower, and shows quite conclusively the impossibility of getting 85 per cent efficiency with 60 per cent excess air even with coal with a heat value as high as 14,688 B.t.u.

Now as to the volume of air which would be needed for the above assumed



"I'm crazy about this semi-outdoor design—I can snatch a sun bath right on the job!"

conditions, since we have calculated 13.7 lb. air per lb. of coal, we must calculate the amount of coal needed for the production of 1000 b. hp.

Coal per b. hp.

$$= 33{,}500/14{,}688 \times 0.85 = 2.69 \text{ lb.}$$

Then, 2.69 times 1000 hp. is 2690 lb. coal per hr., and 13.7 times 2690 is 36,853 lb. air per hr. Since each cubic foot of air at 70 deg. F. weighs 0.075 lb., the volume of air per hour will be,

36,853/0.075 or 492,000 cu. ft. per hr. this is

492,000/60 or 8200 c.f.m.

But as Mr. Patterson points out, usually there is leakage which must be considered so there must be added to the above volume 10 or 15 per cent to allow for this condition. Supposing we are figuring on a stoker fired installation and the stoker manufacturer requires 3.0 in static pressure in the main windbox. Calculations on the duct system might indicate there will be 0.5 in. pressure drop to the fan so the fan should be designed to put up a pressure of 3.5 in. at the fan outlet.

Now, should we specify a fan for 8200 plus 10 per cent c.f.m. at 3.5 in. static pressure? Some engineer might say: "I don't know what the leakage will be so I'll play safe and add 20 per cent to the volume and another inch to the pressure and ask for a fan to deliver 9840 c.f.m. at 4.5 in. static pressure."

But supposing the leakage actually is only 5 per cent and the pressure drop through the duct is only 0.4 in.

This means that the fan should deliver only 8610 c.f.m. at 3.4 in., but if the fan manufacturer is told to select a fan for the larger volume and pressure and were to furnish a radial blade fan operating at 580 r.p.m. at 60 per cent static efficiency, the fan performance might be as shown by the accompanying figure. For 9840 c.f.m. at 4.5 in., the fan will require 11.6 br. hp.:

$(0.000157 \times 9840 \times 4.5)0.60 = 11.6$ br. hp.

This assumes that it would operate on system resistance A as shown by the accompanying curve. But if the purchaser made a mistake and should have asked for 8610 c.f.m. at 3.4 in., then this same fan, when operating on system resistance B, will deliver 11,200 c.f.m. at 425 in. and 580 r.p.m., and will take 12.2 br. hp. if the damper is wide open. To get the volume reduced to 8610 c.f.m., if the motor operates to constant speed, it will be necessary to regulate the damper. The fan will then take 10:5 br. hp.

On the other hand, if the speed could be reduced the fan would need to run only at 509 r.p.m. and then (instead of operating against the resistance of a partially closed damper) with the damper wide open the power required would be 8.25 br. hp., a saving of a little more than 20 per cent.

It should be noted that for stoker firing the system resistance is assumed to be a straight line instead of a parabola square root curve, as in the case of forced draft for other kinds of firing or for induced draft.

FOR THE PLANT ELECTRICIAN

Calibrating a Thermocouple

By FRANK GIBADLO*

SOME TIME AGO I had the occasion to determine the temperature of the flue gases in the stack. There was on hand a Brown pyrometer in good condition and which was calibrated for use with a chromel-alumel thermocouple.

Unfortunately this type of thermocouple was lacking. An iron-constantan thermocouple was available but by using this thermocouple the instrument read about 250 deg. F. too high.

In order to overcome this situation the Brown pyrometer was first adjusted to the zero position or 75 deg. F., which is generally assumed to be standard. If working under different temperature conditions the pointer is set by means of the zero adjuster to that particular temperature to which the cold end is exposed.

If available, a variable resistance is inserted in the negative lead wire, otherwise if fixed resistances are used the cut and try process must be used to obtain the proper resistance value. The thermocouple which is connected to the instrument was placed in the molten zinc which has been heated several degrees above its melting point.

While the zinc is cooling off there is a gradual drop in temperature until the melting point is reached and at that point the temperature remains constant for 15-30 sec. During this period the resistance should be varied so that the pointer on the instrument reads the melting point of zinc which is 787 deg. F.

The Brown pyrometer, rated at 650 ohms and using a standard iron constantan thermocouple read 1030 deg. F. at the melting point of zinc. When this instrument read 787 deg. F., it was found that 180 ohms were required in the negative lead wire.

In addition the instrument was checked against a Leeds and Northrup optical pyrometer. The Brown pyrometer read 1680 deg. F. against 1630 deg F. on the L & N optical pyrometer.

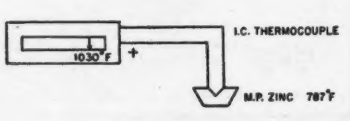


Fig. 1. Without external resistance the instrument read too high

Determination of Unknown Resistances Using a Pyrometer

Unknown resistances can be determined by using the above hookup. By using this arrangement one known resistance is required. For example by inserting a resistance of 180 ohms in the negative lead of the I. C. thermocouple resulted in a reduction of 243 deg. F. (1030—787).

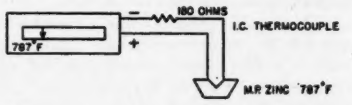


Fig. 2. By inserting 180 ohms in the negative lead the pyrometer indicated the correct temperature

Since temperature readings are directly proportional to the millivoltage produced and the millivoltage is inversely proportional to the resistance in the circuit, the temperature difference is directly proportional to the resistance inserted in the circuit.

In the place of the 180 ohms a rated resistance of 125 ohms was inserted. The temperature reading was 860 deg. F. on the instrument or a reduction of 170 deg. F. (1030—860).

Setting up the equation

$$180:243 = X:170$$

and solving for the unknown resistance

$$X = 126 \text{ ohms}$$

Similarly a resistance of 73 ohms inserted in the circuit gave a temperature of 930 deg. F.

as before

$$180:243 = X:100$$

and

$$X = 74 \text{ ohms}$$

Load Control Cuts Peaks

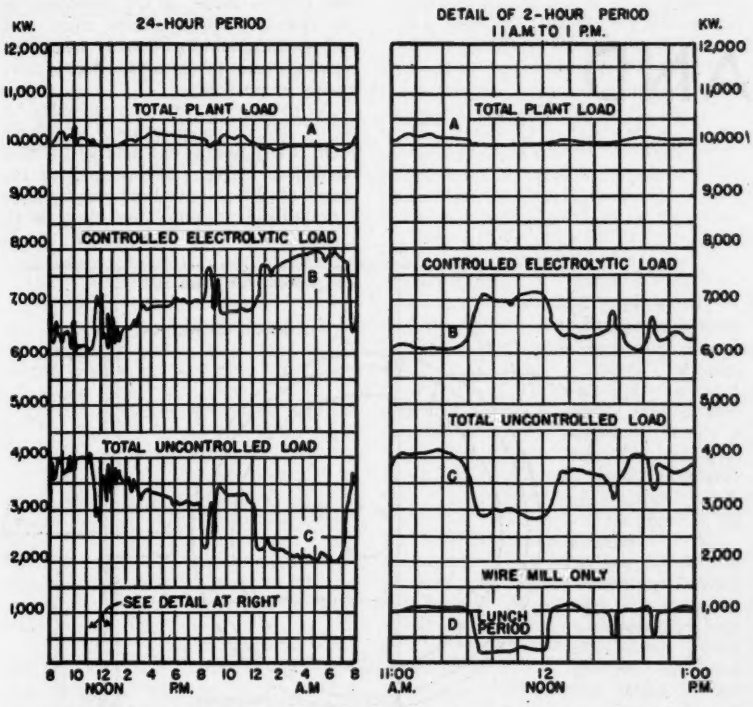
AT THIS time when electric loads are increasing rapidly, and increased capacity difficult or impossible to obtain, effective use can often be made, in industrial plants, of load control or scheduling of department operations.

This was recently pointed out by James V. Alfriend, Jr., as Vice-Chairman of the A.I.E.E. Committee on Electrochemistry and Electrometallurgy. One of the examples he used was in connection with the copper refinery as shown by the accompanying load curves.

Electric furnaces, oil refineries, refrigeration industries, steel mills and even some fabricating industries can operate under variations of this procedure. The degree of control varies with different processes, and with individual installations, and it is maximum, of course, for those new installations which can be designed with this in mind.

There will be few, if any, instances where the load can be reduced to zero for any length of time, but there are no instances where some degree of control cannot be applied.

*Chemist, Salem Gas Light Co., Salem, Mass.



Load Curve of an Electrolytic Copper Refinery showing improvement due to load scheduling
At this refinery the demand of the electrolytic department, which would otherwise be almost uniform, is controlled automatically to compensate for the variable loads of other plant operations to obtain a combined load factor approaching 100 per cent. The chart taken from graphic meter readings, shows that the variations in the electrolytic demand throughout the day were so controlled as to be equal and opposite to those in other plant operations, while the combined plant load remained almost constant. Thus at about 11:30 a.m., the electrolytic demand was automatically increased by 1050 kw., to compensate for the sharp drop in the other loads that occurred when the wire mill shut down for lunch. Automatic control equipment is actuated through relays by the variable combined demand; it changes the field excitation in the motor generators that supply the direct current energy for electrolysis, which in turn changes the direct current voltage and therefore the power drawn by the cells

Synchronous motors are widely used in the many industries to drive mechanical equipment and even direct current generators. In most installations these motors are so controlled as to obtain the greatest power factor correction when they and other electric equipment in the plant are operating at or near full load.

However, during times of controlled low load on such a plant the synchronous motors can be overexcited to obtain additional power factor correction if necessary or desirable. Individually such a corrective contribution may not greatly affect the load but it may on certain feeders. The combined corrective effect of several large process industries will usually materially assist the central stations.

In these cases, it is partly the task of utility systems to determine what needs to be done in this respect, how it can best be accomplished, and to obtain the cooperation of industries by arranging to share the savings which will result.

Maintenance Hints for Industrial Lighting

BETTER PERFORMANCE and greater efficiency at lower operating costs are the direct benefits of a complete inspection and well-organized maintenance program for industrial fluorescent and incandescent lighting.

Luminaires should be cleaned frequently. If dirt is allowed to accumulate on reflecting surfaces and lamps, illumination may be reduced 30 to 50 per cent in a short time. For maximum efficiency, reflectors must be thoroughly cleaned with soap and water. When concentrating high bay reflectors are used, dirt not only reduces total light output but also alters the light distribution.

For example, the efficiency of an aluminum high bay reflector was reduced 42 per cent by dirt, and the candle power was reduced 66 per cent because the distribution was changed. Therefore, illumination on the working plane was reduced about 48 per cent.

When lamps fail they should be replaced immediately with the proper size and type. In large plants, the most effective method is to have a relamping crew patrol the plant regularly. With a properly planned system, the lost lumen hours and the cost of relamping are kept to a minimum. When fluorescent units are used, the lamp fails when the emission material on the electrodes is used up. At this point the lamp will flash on and off and must be replaced promptly to protect the starter and ballast.

For most efficient lighting with filament lamps the luminaires should operate at rated voltage marked on the bulb. Socket voltage below the rated value will reduce light output in the ratio of about 3 per cent for every 1 per cent in reduced voltage. A high voltage will increase light output and lumens per watt, but will adversely affect the life.

Voltage rating of a fluorescent luminaire is marked on the luminaire name plate and ballast, and should be kept at the center of the specified range. Both high and low voltages reduce fluorescent lamp life and may cause starting difficulties and arc instability. Therefore, it is important to make periodic voltage checks to insure continued maximum lamp operating efficiency.

Fig. 1. Cleaning reflectors or lenses at scheduled intervals improves efficiency of industrial incandescent lighting equipment

Blackened and over-age lamps waste current and lower the light output. Worn or frayed wiring can cause circuit failures. Therefore, regular cleaning and wire inspection schedules should be planned, and lamps that have passed their normal rated life should be replaced. Poor connections, faulty safety devices, and mounting fixtures should be regularly inspected. Dirty reflectors, lenses, and lamps may be cleaned easily with non-abrasive soap.

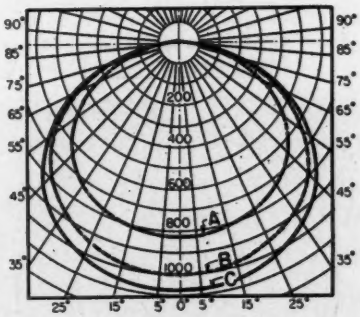


Fig. 2. Effect of dirt on reflector efficiency is shown on this Westinghouse chart made from measurements taken from a fluorescent luminaire installed in a machine shop. The unit had not been cleaned for 12 mo. Curve A shows an efficiency reduction from 79 per cent (when clean) down to 61 per cent. Dry wiping brought the efficiency up to 74 per cent (Curve B), and soap and water increased the output to the original 79 per cent

ENGINES AND TURBINES

Checking Up On An Old Engine*

By E. MacDERMOD

DUE to the national war production effort much equipment, unused and disregarded for years, will be returned to service to assist in handling increased and unanticipated loads. The past history and any previous operating peculiarities of these machines may often be known only by hearsay.

I dislike to be looked upon as an alarmist or a dire-foreboder, but it seems to me that a definite hazard is involved in merely giving this equipment a cursory examination; adjusting here and there, so it won't bounce around on the foundation too much; and then opening the throttle after squirting some oil hither and yon.

Disregarding all other considerations, and to introduce a personal angle, a man has his own hide to think of and a chunk of engine weighing a few hundred pounds doesn't care whose lap it lands in.

N. Y.'s engine is out of line and has given trouble from water in the cylinder. Any person ever having connection with the investigation of engine accidents knows that the mere fact that an engine has withstood a slug of water without being wrecked then and there does not necessarily mean that the engine has completely escaped damage.

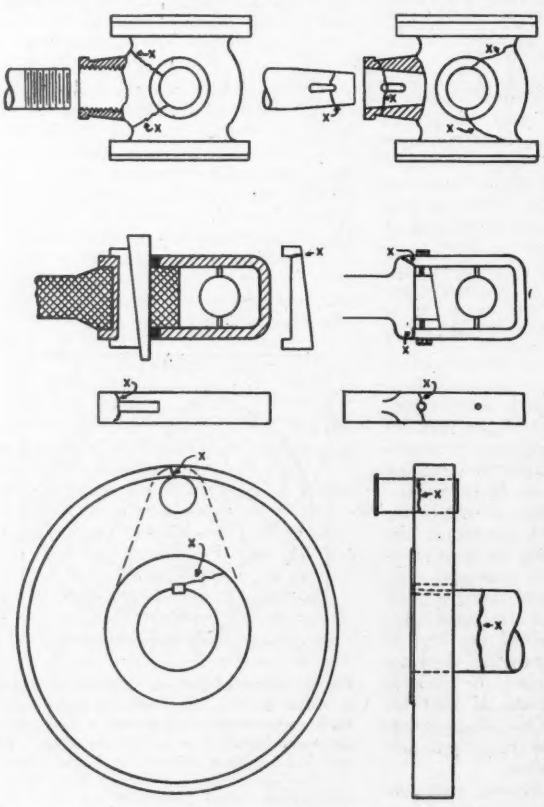


Fig. 1. Cracks are most likely to develop in these parts in the locations indicated by X

The shock resulting from the piston striking water in the cylinder usually means that cracks have been formed at vulnerable points. These cracks progress and result in failure at a date that may be far distant from the time of their inception. Any cracks so formed are materially assisted in their rate of development by the stresses caused by misalinement.

Instead of seeking a quick way of lining up his engine, N. Y. should make as careful an examination of his engine as possible and this means dismantling the engine. It also means that he can do a real job of lining up.

In dismantling the engine observation can be made of the condition of the cylinder, piston, piston rings, rod and packing, and plans made for future repairs or changes not immediately necessary or possible.

With regard to follower-bolts, it would be cheap insurance to renew them if any doubts are held as to their condition. After years of service the metal of these bolts becomes fatigued (crystallized to some) and there is always the possibility of one of them breaking with considerable resultant damage to the engine.

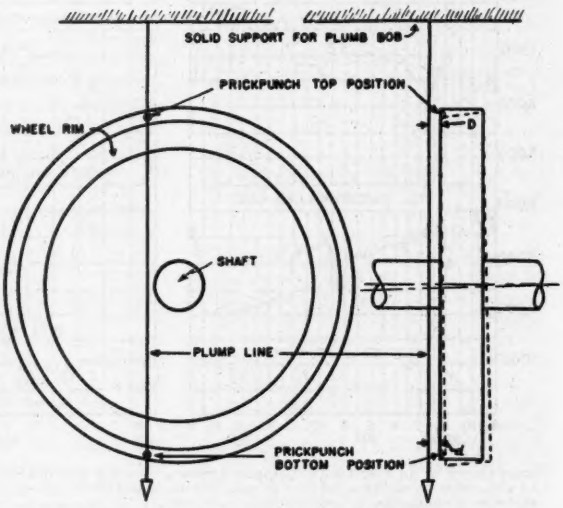


Fig. 2. Using a plumb bob to check the flywheel. Dimension D should equal d

A whitewash test and careful examination should be made of the piston rod end, where it enters the crosshead; the crosshead, inside and out; and the connecting rod ends. The sketches show locations where cracks are likely to exist.

If the engine has been run with the piston not properly centered with the crosshead, that is with either of them high or low with respect to the other, a crack may exist in the threaded portion of the rod, or if the rod is of the tapered fit type, at the points shown on the sketch. The threads within the crosshead may also have been crumbled if the rod has been rocking.

A strap, gib, and key, and a solid end type of connecting rod ends are sketched in Fig. 1 with the likely location of cracks spotted. In applying the whiting test particular attention should be given to sharp corners and around openings, that is where cracks usually originate. Gibs and bolts should not be overlooked.

A cracked crank-pin is difficult to detect as the fracture usually takes place within the crank arm or disc.

* This was originally written as an answer to Question No. 157 (p. 93 of the March issue) asking how to go about checking up on an old engine, with a rather indefinite history of trouble, which was to be put back in service. Because of its length and timeliness it was changed to an article. Additional answers, together with Mr. MacDermod's comments on barometric condenser troubles connected with the particular engine, will be published next month in the Questions and Answers Section under the above title.

Fig. 3. On the crosshead tram between the two punchmarks C the distance should be the same on both dead centers

Drilling to a considerable depth along the axis of the pin and beyond the surface of the arm or disc, and devising some means of applying an impact hydraulic pressure has been known to give good results. I do not think it necessary to carry the inspection to this extreme unless there is some definite indication of a cracked pin. One such indication is explained later.

In whitewashing the crank arm or disc, cracks are frequently discovered that originate at the corners of the keyway (see Fig. 1). Unless these are of undue length and extend well out into the arm or disc, they should cause little concern. However, the ends of the cracks should be carefully located and prickpunched so that they can be observed occasionally and any further development noted.

Accessible portions of the crankshaft should be whitewashed and close examination made of any abrupt changes in diameter and of fillets. However, my experience has been that the cracks usually develop within the hub of the crank, or within the hub of the wheel, where they couldn't be seen anyhow.

One commonly disregarded indication of the existence of a crack is the continual, unaccountable, and excessive heating of a bearing. Ordinarily a crack progresses for a long time before it reaches the point where failure takes place, and the constant flexing of the part causes heating to take place just as bending a wire back and forth will cause the wire to become hot. Bearings that heat excessively for no apparent reason should be very carefully investigated.

In making a whitewash test I have always slopped kerosene on the part liberally (small parts can be dumped into a bucket) before wiping the part dry and painting with a mixture of water and whiting. I think that the kerosene penetrates any defect and will show up better than depending upon entrapped lubricating oil. Also I have had better results with water rather than with alcohol (in more ways than one). Considerable time should elapse after the whitewash has dried before concluding that, because nothing shows the part is free from defects. Overnight is desirable if possible.

It might be well to mention here that before purchasing any second hand engines, examination of the parts referred to in the preceding might prove a profitable procedure. No reputable dealer should refuse a prospective customer the right to make careful examination of a contemplated purchase, in fact I think he should be willing to bear the expense.

Now, if after that preamble one still wants to know how to line up his engine quickly, he can do the following:

If a satisfactory spirit level is not at hand or space on the shaft is too restricted for its use, drop a plumb line alongside the flywheel and near the shaft. On the wheel near the top prick-punch opposite the line and measure the distance between the mark and the line. Turn the wheel until the mark is on the bottom and again opposite the line, and measure the distance here between the mark and the line.

Any difference in measurement will mean that the shaft is not level. Usually the engines main bearing is low as it receives more wear than the outboard bearing. If care is exercised this method is more accurate than using a level and it makes no difference if the wheel is not true.

Assuming that the crosshead guides are in line with the cylinder and that the crosshead and piston are properly centered it can be determined whether the shaft is at right angles to the engine's center line by putting the engine on dead center, loosening the wrist pin bearing and jamming up on the crankpin bearing. Tram between a point on the connecting rod and one on the crosshead.

With the engine on the other dead center and crankpin bearing again jammed up, measure the distance between the same two points. It may be necessary to support the weight of the connecting rod so that it will be free to swing when the crankpin bearing is tightened.

Differences in measurement indicate misalinement. There is a chance for all kinds of errors in doing this, but it is at least as accurate as stringing a line outside the cylinder and guides in the majority of cases.

Draining Turbine Extraction Piping

By S. H. COLEMAN

STEAM PIPING connecting the extraction nozzles of industrial bleeder-condenser turbines to the plant steam distribution systems is usually designed so that a positive means of drainage is an absolute necessity. This need can best be visualized by referring to the typical extraction steam piping layout in the accompanying diagram.

Here, a characteristic of most turbines of this type, the extraction nozzle is located on the underside of the machine. Expansion joints are provided in the piping to protect the nozzle from undue strains due to temperature changes and to compensate for both vertical and horizontal movement.

Another feature, a non-return valve, is needed as a safeguard against the backflow of steam from the distribution piping. This might well cause the unit to overspeed should the throttle valve be tripped or other abnormal operating

(*Continued on page 92*)

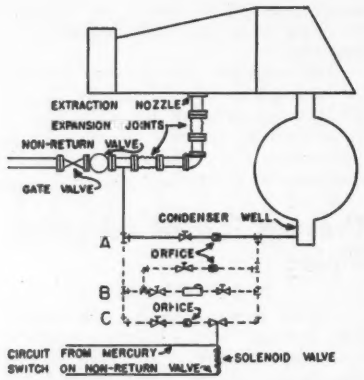
Turbine Shaft Repaired by Metal Spray Process

RECENTLY a middle west power company was forced to shut down a 6000-kw. steam turbo-generator because of two worn areas on the water seal section of the forged steel shaft. One worn area was approximately 3 in. wide at the 11 in. diameter section of the shaft, the other 2 in. wide where the diameter was 10½ in. Since this 36,000-lb. rotor, balanced to keep the vibration within 0.001 in., is subjected to heavy duty, it was decided to effect a repair with Mogul Metallizing using No. 2 eleven-gage stainless steel wire.

Worn sections were first undercut about 3/16 in. and then grooved and knurled. A rig was hooked up on the bed of the turbine to accommodate the cutting and knurling and to hold the gun during the spraying operation. An electric motor with a reduction pulley arrangement was rigged to the turbine end of the shaft and revolved the shaft at a speed of about 5 r.p.m. during both the preparation and spraying operations.

An auxiliary air jet was played upon the opposite side of the shaft for cooling purposes. Following the spraying, the shaft was ground to size and re-assembled in the generator. Propane gas was used, and the entire job was completed with 40 lb. of wire and in 7 hr. While the turbine was down, a part of the shaft which had been similarly metallized 3 yr. ago was examined, and it is said no appreciable wear could be detected.

Set-up for repairing a 6000-kw. turbine shaft by metal spraying. The gun spraying No. 2 stainless steel is on the extreme right and the turning gear for slowly rotating the shaft is on the extreme left. Notice the eccentric drive shaft with two universal joints



Three methods of draining the extraction piping. A (solid lines) by means of an orifice. B (dotted lines) by means of a float type drainer. C (dashed line) by an automatically operated solenoid valve. Note that when B is used A should be used also to act as a bypass around the drain

conditions develop. A sectionalizing valve is also provided between the non-return valve and the distribution system piping.

A glance at the diagram will show that whenever the non-return valve is closed, steam condensed will be trapped, and the pocket will fill unless some means of drainage is provided to remove condensate as fast as it is formed. Without this drain, liquid may accumulate until it reaches and endangers the turbine blading, or serious water hammer may be experienced in the distribution piping when the extraction gear is placed in service forcing the non-return valve open, and suddenly releasing the not inconsiderable volume of condensate.

Because of the widely varying pressures that exist in extraction connections under different local conditions, drainage of these connections is not so simple as it may seem. When starting up, or, operating at light loads, the pressures within the piping are seldom much in excess of atmospheric and are usually in the sub-atmospheric range. With the extraction gear in service, however, with steam extraction from the turbine, no drainage is ordinarily required unless for some reason the piping is otherwise pocketed.

One widely used method of draining these connections is shown with solid lines in the piping diagram. This method makes use of a flow limiting orifice placed in a drain line connecting the lowest point in the extraction lead with the condenser hotwell. Such an orifice is usually a small hole drilled in the gate of an ordinary gate valve. The opening should of course be sufficiently large to adequately handle, with a reasonable factor of safety, all the liquid which might otherwise accumulate in the extraction connection.

In calculating orifice size it is necessary to take into consideration the small pressure differential which exists across the low pressure stages of the turbine when starting up or operating straight condensing. Unfortunately this means of drainage has a major drawback, namely, that when steam is being extracted a much higher differential will prevail across the orifice allowing a prohibitive quantity of high heat level steam to bypass the low pressure stages of the prime mover. Installation of a shut-off valve, between the drain connection and the orifice, to be kept closed when the extraction gear is in service and left open at all other times, will eliminate most of this loss.

As with all control valves subject to manual operation, the opening and closing of this shut-off valve in the drainage line is subject to the vagaries of the human factor entailing the possibility of danger or of extensive heat balance losses. An alternative automatic method shown with dotted lines in the diagram is to use a float type trap equipped with a sight glass and designed to operate at all points in the pressure range existing in the drainage hook-up. Such a trap must of course be provided with a bypass to allow its removal from service for maintenance, and it should be closely watched by the operator.

A more elaborate drainage control but one that is practically fool proof, is shown with the broken lines in the diagram. This method involves use of a mercury switch mounted on the balancing arm or swing shaft of the non-return valve. The switch is adjusted so that when extracted steam is flowing and the valve disc is open an electrical circuit is closed, shutting off a solenoid operated valve in the drainage line between an orifice and the condenser hotwell. To avoid difficulties which might arise should there be a failure of the electrical control circuit, the solenoid valve should be of a type which will close only when energized and will automatically open should the circuit be broken or the power fail.

Three "Stop Worry" Hints for Operators

By A. H. PARKER

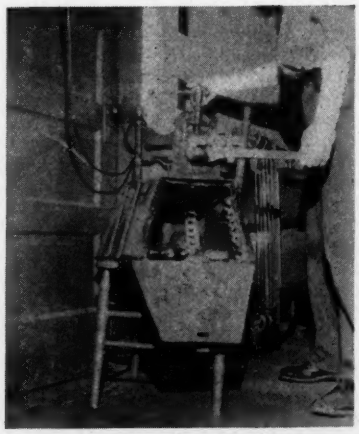
We have used a number of two cell lanterns which are economical, long-lived, and easy to maintain, and while we seldom use them, they must always be available. However, I have never known one of them to have a switch worth a continental. They flicker and eventually become so worn that they have to be held in. I equip each and every lantern with a 10 ct. porcelain knife switch, mounted on the cover. There is no more flicker and a continuing steady light for the life of the batteries.

Some years ago I needed a float shut off for the storage tank on the feedwater line. I had some old discontinued Armstrong traps in the junk heap and I took out one of the discharge mechanisms, turned it bottom side up, and it works to perfection. I had never heard of this contrivance which saves me so much work and worry. An unlimited number of other guys may have something like it but I had never seen one.

On our heating system return lines there are modulation traps, the purpose of which is to remove the air from the system and discharge it to atmosphere. When I took over, and after much misery, I found the discharge lines completely choked with rust. I corrected this condition, but results were still unsatisfactory.

Eventually I figured out a vacuum return. I only use it when the heating is intermittent or there is a hurry call, when in short, someone wants to know if "that damned engineer is dead or only sleeping." I have connected a line from the traps to the suction of my Hancock Inspirator and by opening or closing the proper valves, can pull up to a 10-in. vacuum on the system in no time at all. And, boy, it certainly pulls the steam through the most distant radiators like nobody's business.

Combination Vise and Tool Box Saves Time



WHEN building or repairing small pipe lines or conduits, plumbers and electricians often find a vise tripod a very unhandy piece of equipment to haul around. By building the box with a broad bottom and fastening the vise to the top, the tool box may be made to take the place of a tripod, and may be set in more convenient places. Photo "a" shows the box closed, with a piece of pipe in the vise. Photo "b" shows the box open and in use— GEORGE HOLMAN

Questions And Answers

Should the Heating System Be Drained?

PLEASE give me an answer to the following problem: Should a hot water heating system be drained during the non-heating season or left full of water? Why? J. O. R.

Answer No. 125

Well, Blow Me Down! What a Hookup

ON PAGE 80 of the June issue Mr. Kilpatrick makes what I think is an unjustified attack on Mr. Hallquist for I believe his views regarding blow-off valves and/or cocks do not reflect consideration of all points and proper sense of values. Either type of appliance is best adapted for a certain class of installation and although their application may at times apparently over-lap, consideration as to their relative merits, first cost, and the service to which the valve or cock is subject should enable one to make the proper selection.

Although the installation of a plug cock in the blow-off line of a 1200 lb. boiler might be awkward, a seatless piston type valve in the blow-off of a teapot H.r.t. would be unnecessary dress-up and probably an indication that the engineer was sort of reckless with his employer's money. As to blow-off cocks being as out of date as bustles and model T Fords, cocks are still being made, sold and installed (unless Nelson has done some more red-flagging) so they can hardly be classed as being obsolete.

I would also venture to say that there has been as little (or the least) opprobrium and invective slung at the type referred to by Mr. Hallquist, as at any piece of regularly used equipment around a boiler room. I personally have used plenty of lurid language, as have others of my acquaintances, in description of the type of valve of which Mr. Kilpatrick is so fond.

Melrose, Mass. E. MACDERMOD

Answer No. 143

Solid Equivalent of a Stranded Conductor

JACK ADAMS asked on p. 96 of the December issue how to determine the equivalent size of a stranded conductor, specifically one with seven No. 12 wires.

If you have wire tables—

TO FIND the diameter of a solid wire to carry same load as a stranded wire with seven No. 12's, look in your table for the current capacity of one No. 12 and multiply this by seven. This will be the ampere capacity of the stranded wire. From that capacity and the same tables determine what gage of solid wire this is equivalent to. If your table doesn't have that, work out the cross sectional area of the seven No. 12's in circular mils. To find what solid wire has the same cross sectional area is then simple arithmetic.

Newton, Pa. O. H. WARNE

For the Size Mentioned Here Are the Figures

BY USING a circular mil basis the solid equivalent of a stranded conductor can be calculated. Using the example given by Mr. Adams and consulting the wire tables we find that No. 12 wire has an area of 6530 circular mils or the stranded conductor has a total area of 6530 times 7 which equals 45,710 circulars of conductor. Referring again to the wire tables we find that the solid conductor we need lies between No. 4 and No. 3 wire. The actual use of the wire would determine whether No. 4 or No. 3 wire should be used.

Southwestern G. & E. Co.
Shreveport, La. W. C. MORRIS, JR.

But the Insulation Must Be Considered, Too

AS THE conductivity of a conductor is dependent upon its cross-sectional area, a solid conductor having the same capacity of a stranded cable of seven No. 12 strands, would have an area of 45,710 cir. mils. This is a cable between Nos. 3 and 4 in size, and as per the Code would be allowed to carry from 85 to 95 amp., with varnished cambric insulation.

This load is considerably less than seven No. 12 wire would be allowed to carry as individuals, because of factors concerning insulation, and the difference in heat dissipating capacity between seven conductors acting individually, and one conductor acting alone. A condutor large enough, in varnished cambric, to equal the conductivity of seven No. 12 wires as units, would be of No. 00 size.

SAM WILLIAMS

If You Want to Work It Out in Longhand

SOLID equivalents of stranded conductor is something I have never seen in table form and I think it would be a rather lengthy one due to the many wire sizes used. Here is a formula I have used with good results.

Cir. mils. $\times$ 0.7854 = sq. mils.

Take, for example, 7 strands of No. 12 wires. One No. 12 wire = 80.8 mils. in diameter or 6530 c.m. First we must convert one No. 12 wire to square mils. Thus 6530 c.m. $\times$ 0.7854 = 5128.66 sq. mils. in one No. 12 wire.

There are 7 wires, so 5128.66 sq. mils. $\times$ 7 = 35,900.62 sq. mils. in the solid block of copper. Now we must convert our square mils. back to c.m. by the formula:

Sq. mils. $\times$ 1.2732 = c.m.

So 35,900.62 $\times$ 1.2732 = 45,708.66 c.m. of solid round wire is equivalent to seven No. 12 wire cable. In practical work drop the decimal.

This formula can be used for any size of wire in any cable. All you need to know is the circular mils. of one wire.

Newark, N. Y. LEO S. SWARTZ

Just in Case You Are Interested in Other Sizes

THERE IS only one way that I have ever heard of for computing the solid equivalent of strand wire and that is to gage the size of one of the strands of wire, find the area in circular mils., then multiply this by the number of strands in the wire. The size wire that has a circular mil. area nearest to the combined area of all the strands is the solid wire equivalent. The solid conductor equivalent of seven No. 12 wires . . . equals 45,710 c. m. The nearest to that is No. 4 with an area of 41,740 c. m. As a rule all sizes of strand wire from Nos. 14 to 2 have seven strands, Nos. 1 to 0000 have 19 strands, 250,000 to 450 000 c. m. have 37 strands, 500,000 to 1,000,000 c. m. have 61 strands, and 1,250,000 c. m. has 91 strands.

DONALD OSTERHOUDT

Poughkeepsie, N. Y.

For Those Who Want ALL the Details

TO DETERMINE the solid equivalent of a stranded conductor, using Jack Adams' own problem as an example, proceed as follows:

The cross-sectional area of a No. 12 copper wire is 6530 c. m., from which the total area of the seven strand cable is 7 $\times$ 6530 = 45,710 c. m. This lies between a No. 3 and 4 cable. For a solid wire the radius

$$r = 0.0005 \times \sqrt{C.M.}$$

The square root of 45,710 = 213.8, from which $r = 0.0005 \times 213.8 = 0.1069$ in. The diameter of the equivalent solid wire is therefore $2 \times 0.1069 = 0.2138$ in.

Since this is not a standard size wire it may be of interest to carry the work a step further. For example, in computing the inductance L and the reactance X of stranded conductors, the actual radius of the cable (as is the case with solid wires) cannot be used. Instead, however, what is called the equivalent radius of the stranded cable must be used. For a seven strand cable

$r = 0.0005285 \times \sqrt{C.M.}$,

which in our case is equal to $0.0005285 \times 213.8 = 0.11299$ in.

$L = 0.08047 + 0.74113 \log_{10}(D/r)$ (Eq. 1)

Where:

L = inductance in milihenries per mile of single conductor.

D = equivalent spacing of conductors.

r = actual radius of solid and equivalent radius of stranded conductors, respectively, in same units as D (usually in inches).

Substituting the known values in Eq. 1 and solving for L, we have

Solid wire L = 1.59992 milihenries per mile.

7-strand L = 1.58209 milihenries per mile.

The reactance $X = 2\pi fL$, where L is in henries per mile. The reactance at 60 cy. is:

Solid wire, $X = 376.99 \times 1.59992 \times 10^{-3} = 0.60315$ ohm per mile.

7 strand, $X = 376.99 \times 1.58209 \times 10^{-3} = 0.59623$ ohm per mile.

Assuming hard drawn copper, the resistance at 25 deg. C. is 10.659 ohms per mil. ft. Since the resistance varies inversely as the cross section, $R = (10.659/45{,}710) \times 5{,}280 = 1.2313$ ohms per mile. For seven strand add 2 per cent to compensate for the effect of stranding for an equivalent solid conductor. Thus $1.02 \times 1.2313 = 1.2559$ ohms per mile.

Since this is not a standard size conductor, these values will not be found in any of the resistance and reactance tables.

Raleigh, N. C. F. C. DeWeese

The Arithmetic is Not Difficult

An answer to this question can be readily obtained by well known fundamental calculations. Given any group of circular conductors the total area is:

$$\pi(d^2/4)n$$

where d, the diameter of each strand in some units, usually in mils. (one-thousandth of an inch), and, n is the number of strands in the cable. The total area will be either in square inches or square mils. depending on the unit used for expressing d. When the total area is obtained, the solid equivalent conductor may be obtained directly from a table or the actual diameter by calculation. If we call the total area A and the diameter of the equivalent solid conductor D, we can write:

$$A = \pi D^2/4 \text{ or } \pi d^2 n/4$$

then equaling these two, and, since $\pi/4$ occurs in each expression we can eliminate this part from each one and write, $D^2 = d^2 n$ for the equivalent areas.

Taking the example given, a cable made up of seven No. 12 wires, we find from a wire table that d is 80.81 mils. Therefore d^2 would be 80.81×80.81 or 6530 (known as circular mils.) and the total cable area will be 7×6530 or 45,710 circular mils.

This total value indicates a solid conductor which lies between No. 4 (41,740 circular mils.) and No. 3 (52,640 circular mils.). The actual diameter of a conductor having an area of 45,710 circular mils. can be obtained by taking the square root of this value, which is 213.79 mils. The respective diameters of No. 4 and No. 3 solid conductors are, 204.3 mils. and 229.4 mils. In inches the diameters of the solid conductors would be 0.21379, 0.2043 and 0.2294. This illustrates the advantage of using the mil. unit and avoiding thereby the decimal details.

C. O. von Dannenberg
Brooklyn, N. Y.

Answer No. 153

Will This Shut the Boiler Down?

Answers to T. R. E.'s question published on p. 96 of the February issue are conflicting, but the concensus of opinion is that it is not likely to shut the boiler down immediately but leaves a condition that favors corrosion and trouble in the end. T.R.E. has cross-drum boilers baffled for three passes. Equipment recently installed makes it impossible to reach the lower three rows of the first pass, and, the upper three rows in the second pass, with a steam lance as was formerly done. He wanted to know what effect might be experienced from leaving ash and soot collect undisturbed on these tubes.

It Cuts the Draft and Causes Corrosion

If tubes are not blown regularly, sections where the tubes are rolled into the drums or tube sheet will gradually collect fly ash and soot. The corners where the gases are slowed down or sections not in the line of high gas velocity will fill first and plug up. I have seen tube passages almost filled up because of laxness in blowing tubes.

This causes a loss of overfire draft and inability to carry loads and to burn fuel efficiently. In one instance with the damper wide open the overfire draft was 0.35 in. and in about 3 wk. it dropped to 0.175 in. because of accumulation in the different passes. The boiler had to be shut down because it could not carry the load.

Another thing that cannot be overlooked is that where these accumulations are and moisture is present, pitting and corroding of the tube ends and tube sheet begins and many times is the cause of tube and plate failures.

Maywood, Ill. George W. Redman

It Cuts Down Efficiency and Capacity

Probably T. R. E. will find that the soot and ashes in the second pass of his boiler will not cause serious trouble although it will lower the efficiency of the boiler. However, if the boiler setting is low he will have trouble with slag in the first pass especially when the boiler is operated at 200 per cent rating. It will very likely be necessary to shut down the boiler about once a week to clean out the slag from between the tubes.

Some trouble may be avoided by keeping the over-fire draft as low as possible so that the fly ash is not carried into the tubes. The air for combustion can be supplied by increasing the pressure in the wind box under the fire.

Leaving soot and ashes accumulate while the boiler is in operation will only lower the output and efficiency of the boiler. If the accumulation is left on while the boiler is out of service it will become moist and cause corrosion on the outside of the tubes.

Lombard, Ill. Harold D. Brown

Feels It's a Regrettable Incident

Sooner or later, the boiler will have to be shut down, especially, if the high volatile fuel is used as indicated. The reason for this is that the soot from the volatile constituent settles on the three lower rows of tubes. If the boiler is always overloaded, as I gather, the spaces between adjoining tubes will be filled rapidly and a cake like mass will impede the passage of the gases resulting from combustion. Result: gas pockets which have no place in an economical operation of any boiler.

There would be no danger of a tube collapse, but in no time it shall be difficult to maintain the steam pressure needed for the operation of the prime movers. Because the soot and ashes between the tubes are very good insulators and before heat is imparted to the rest of the boiler, the cake like mass must be kept in a glowing condition.

It is certainly a regrettable incident to install equipment which hinders the boiler operator from cleaning the tubes properly. After all, there is no sense in cleaning one passage if the lower rows of tubes cannot be kept clean in order to obtain an unrestricted passage for the product of combustion.

Glendale, L. I., N. Y. C. Carl Egerter

But Soot Blowers Should Fix Things Up

It is doubtful whether the boiler which T.R.E. is operating will be forced to shut down because of soot accumulations. However, one or more of the following conditions may be caused by the excess accumulations and the boiler will eventually have to be shut down for cleaning. It is obvious that the time intervals between cleaning will be shortened.

1. The heat transfer rates through the unclean tubes will be cut down.

2. The remaining portions of the tubes will be subjected to more heat and will be required to generate more steam than formerly. They will therefore be overloaded.

3. Water circulation through the tubes may become erratic.

4. The tubes which are kept soot free will have higher heat transfer rates with the resulting possibility of greater scale deposits on their interior surfaces.

5. Excess soot on the outside of the tubes might set up corrosion when it combines with the unconsumed hydrogen and sulfur in the flue gases.

6. Draft through the boiler may be cut down. As a result the forced draft fan may be overloaded.

7. Flue gas temperature may be higher.

8. The efficiency of the boiler as a whole will be cut down.

The only solution seems to be in the installation of one of the patented soot blowers on the market.

Bronx, N. Y. C., N. Y. TYLER G. HICKS

A Dynamic Remedy—Use Strictly According to Doctor's Orders

LETTING soot and ash accumulate on the tubes will run the fuel bill up, decrease the boiler output, and cut the draft down, but will not immediately hurt the tubes. Soot and ashes on tubes will act as an insulator against heat; will also help to close in on the draft space between tubes, forming increased resistance against air and gas flow.

If there is no possible way of cleaning those tubes then; open the damper wide; put a little gasoline (or any kind of explosive) in a pint or half pint bottle, well stopped; wrap it in plenty of paper; throw it in the boiler through the fire door; and, close the door quickly. This will make the boiler back fire and blow the soot and ashes through the stack. BE SURE THE DAMPER IS OPEN before doing this and also experiment a bit on a small scale according to the size of the boiler.

New Orleans, La. GEO. DEICHMAN

Use Instruments to Check the Effect

T.R.E. does not state whether the baffles are horizontal or vertical, but from the description given it may be inferred that they are vertical. I do not think that he will have any difficulty in operating this boiler for several months at a stretch without blowing the tubes. It may be possible to do it for a whole year, but it is pretty certain it can be done for 3 mo. If the baffles are horizontal, 1 mo. may be the longest period before the boiler has to be taken down.

These statements may be questioned by many engineers because in the orthodox way the tubes of a boiler are supposed to be blown three times per day. But I know what I am talking about because I have let a boiler go without blowing the soot for a whole month with negligible rise in the flue gas temperature and draft loss. On that basis the boiler could have gone several months before the gas temperature rise or draft loss would be appreciable.

T.R.E. need not fear any serious consequences provided he is on the alert to watch for any changes in the flue gas temperature and draft loss. My advice is that boiler be equipped with a draft gage and flue gas thermometer. These should be watched daily. So long as the draft loss does not increase beyond the draft needed, the capacity of the boiler will not be lessened. The flue gas temperature will tell him when it will pay to take the boiler down for cleaning. For each 25 deg. rise in temperature, the fuel loss is 1 per cent.

Joliet, Ill. N. T. PEF

Finally a Pessimist But He Speaks from Experience

THERE IS little doubt that T. R. E. is in for trouble because I had a similar experience 2½ yr. ago when my partner and I were placed in charge of the plant where we are now working. The plant consists of two 150-hp. boilers. Former engineering practice had not included cleaning the soot off the tubes.

These boilers have 96 tubes, 3½ in. by 16 ft. each, eight of which are generating tubes and the remainder circulating tubes. The build-up of the fire box contains a shell just under the front and rear tube headers. On the rear shell soot had accumulated until it completely covered the rear portion of the generating tubes and had partly covered the first row of circulating tubes.

Our first job was to clean the boiler thoroughly on the fire side and as thoroughly as time would permit on the water side. Twenty-four hours after firing up No. 2 boiler one of the generating tubes failed. Examination showed that the failure was due to the etching action of carbonic acid formed by the combination of carbon from the soot and water from the atmosphere.

As the acid was most active when the boiler was shut down we were able to tell, by counting the etched rings, just how long it had been since the tubes were cleaned—4 yr. In fact we learned that the generating tubes on that boiler had been replaced about 4 yr. previously and several times in the last 10 yr. Further examination showed all generating tubes in both boilers to be in about the same condition which meant the replacement of 16 tubes.

We have increased the operating time of the boilers from 10½ hr. per day, prior to our taking over, to the present 12 hr. per day. Our load has been increased about 5 per cent in addition to that, but, our fuel bill runs from 15 per cent to 20 per cent less than it formerly was. That soot must be removed.

Venice High School JOHN W. EAKER
Venice, Calif. Engineer

Answer No. 173

His Compressor Pumps Oil and Frosts Badly

TROUBLE with excessive frosting and oil pumping with a recently overhauled ammonia compressor was reported by H. B. N. on p. 122 of the May issue. This was answered in the same issue by D. F. Hill. He outlined the possible reasons behind the trouble and said changes would have to be made to insure only dry gas reaching the compressor.

Carl Thinks the Water or Evaporator May Play a Part

THIS question was ably answered by Mr. Hill but it seems that there are three more possibilities for the compressor to pump oil and frost excessively, namely: scored cylinder walls; a scaly water jacket; and badly frosted evaporator coils.

In a scored cylinder wall the small scratches will force the lubricating oil past the valves and as a consequence it will mingle with the vapor. A reboring job would be necessary to do away with it.

If the water jacket is rusty and muddy the pre-cooling process of the vapors is diminished. Flushing of the water jacket is advisable, and, water softener, a necessity.

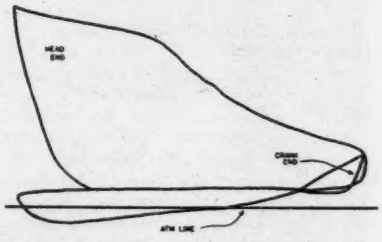
In the case of badly frosted evaporator the heat transfer is low and the suction side of the compressor is more likely to get wet vapor. To eliminate the frost or ice I would keep the air in the storage room as dry as possible, or, attach a line to the high pressure side of compressor, connect it to the evaporator coils and defrost them at regular intervals.

Glendale, L. I., N. Y. CARL EGERTER.

Answer No. 175

Ed's Engine Works Down But Not Up

ALTHOUGH I've never seen a vertical Fitchburg engine, I have inspected plenty of other types of the same make so will enter my ideas anent E.S.P.'s indicator card appearing in the June issue, p. 78.



Indicator Card referred to reduced to half size. It was reproduced full size on p. 78 of the June issue

Having a very suspicious nature, I don't think that Ed submitted that card for comments with an intent that was entirely pure. It may be that there is some dis-arrangement of the crank and steam valve, but what I think is more likely is that the head end card was taken while the engine was carrying load and that between cut-off on the head end and admission on the crank-end that the load was dumped, with the result that the crank-end got no steam.

If I'm wrong I apologize, if I am right Ed deserves a medal and commendation for his perseverance as it takes a lot of persistence and forebearance to get a card like that. Maybe the card actually obtained wasn't as clear cut as the one illustrated as you mention that the one received had been traced over. Such skulduddery!

Incidentally the head end looks as though the valves had been set for condensing operation with that much compression and no load.

Melrose, Mass. E. MACDERMOD

EDITOR'S NOTE: *While Mac's suspicions may on the surface seem justified, we assure you that Ed was sincere and the card was not a fake. The trouble has been corrected—how will be told next month in Ed's reply to the above letter.*

Answer No. 176

Gage Calibration

J.K.R. may find the suggestion, listed below, helpful to his problem as stated on p. 78 of the June issue.

Gages that are calibrated correctly need show no change in readings after a 6 mo. period. Ammonia gages have tubes and connections made of steel instead of brass, and this construction is upheld by gage makers. On account of the possibility of ammonia leaking from the gage tube, it is often considered advisable to fill the gage pipe with oil. This oil is usually the type used for lubricating the compressor.

The oil should be filled in for a short distance above the gages, upon which the pressure of the gas will act, causing a gage to move properly but without allowing the ammonia gas to enter the gage. Standard practice called for by engineers is a frequent check up of gages, instead of the once a year policy to insure accurate gages, as serious damage may result in wrong indications of pressure.

MARTIN N. GOZDENOVICH
Fairview, N. J.

Calibration Usually Changes Only in Operation

ON GAGE calibration, I would like to say that, from my experience, I have found that a gage loses its accuracy only during operation, and then usually only when abused. Excessive heat, excessive pressure, pulsation of the fluid, vibration of nearby piping, hand working loose, etc., are the more common causes of gage inaccuracies.

GEORGE HOLMAN

Answer No. 178

If the Brine Pump Stops?

"WHAT WILL happen and why, if an ice machine is in operation and the brine pump stops and is not started again" (Question No. 178 asked by J.K. on p. 78 of the June issue) depends upon the method of feeding the liquid refrigerant to the brine cooler or tank coils.

If the liquid is admitted to the cooler or coils by means of a properly installed and properly operating float regulator, the liquid on stoppage of the pump or agitator, will rise till the float stops admission by closing the port. The needle will not seat tightly, or for long, however, for evaporation will not cease entirely because the liquid refrigerant will continue to draw heat from the stagnant brine, and from itself.

As the compressor continues to operate, the pressure of its own vapor upon the liquid falls. By evaporation the liquid becomes colder. As the temperature difference between the liquid refrigerant and surrounding brine becomes greater heat flows more readily from the brine to the liquid until the congealing temperature of the brine is reached, and it begins to sludge up on the brine side of the pipes or tubes.

Neither salt brine nor calcium chloride brine will ordinarily form a compact crystalline mass as does water, so there is little danger of bursting a pipe or vessel by freezing of the brine. But as the compressor continues to operate, the sludge line will extend farther out from the coils in a brine tank, and farther along the pipes leading to and from a shell type cooler.

How cold the liquid refrigerant will get depends upon the height of vacuum the compressor can pump. If a compressor can pump down to 20 in., the temperature of the liquid refrigerant (if ammonia) will be reduced to minus 64 deg. F. Even at this temperature, the liquid will lie at its normal level in the cooler or coils.

In a system fed by a float regulator in proper order, and with no bypass expansion valve in use or leaking, the compressor is in no danger provided the pump or agitator is not started. In case the pump has been stopped more than a minute or two, the suction valve of the compressor must be closed before the brine is set in circulation again, for if solidification of the brine has proceeded far enough in a shell type brine cooler, starting a brine pump of the reciprocating type may burst a pipe or tube.

If the brine can be circulated, starting any kind of pump or agitator will endanger a compressor having its suction valve open more than a quarter turn. Comparatively warm brine thrown against heat transfer surface with extremely cold liquid refrigerant on the opposite side will set the liquid to boiling violently, with resulting carryover of liquid to lift the safety heads of the compressor.

In contrast to a system fed by a float regulator, stoppage of the pump on a system fed by an expansion valve immediately endangers the compressor. The time required for flooding to commence depends upon the original height of the liquid in the coils or cooler, how widely the expansion valve has been open, suction and discharge pressures, etc.

If the liquid level is kept so high that the heat transfer surface is working at capacity, flooding may start within a minute or two if the compressor and expansion valve were also operating at capacity. At low liquid level and an almost closed expansion valve, coupled with a large coil capacity, flooding might not start within an hour.

But flooding is certain to come. It becomes noticeable by the frosting back of the suction line, the compressor suction manifold, sometimes around the cylinders, and by cooling of the compressed gas discharged from the machine. In high-speed compressors with poppet type valves there is usually a warning click or two, then a violent and rapid rat-a-tat-tat, followed immediately by the heavy pound of safety heads lifting. In extreme cases a head is knocked off, a piston or piston rod broken, or some other damage. In case a safety head lifts, it should be reground to prevent leakage past its seat.

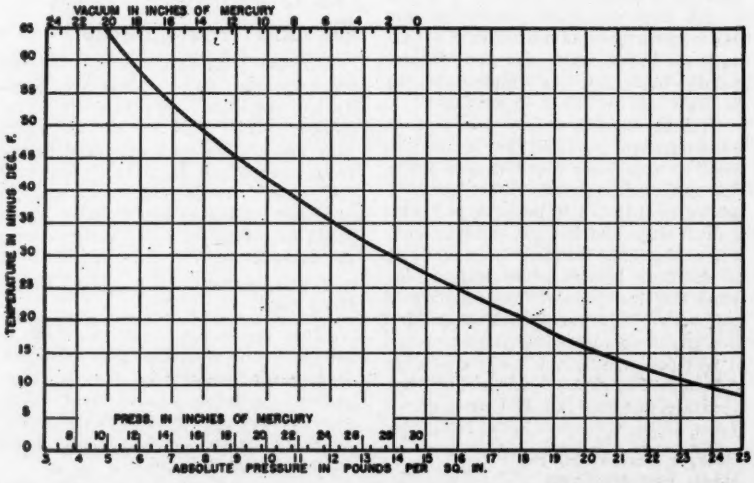
Should the operator of a refrigeration system discover that the pump or agitator has stopped, his first act should be to close the expansion valve, or otherwise shut off the flow of liquid to the cooler or coils. Then the suction valve on the compressor manifold should be closed, or nearly so, until investigation shows whether or not the brine has sludged up. If a cooler has filled with sludgy brine, the compressor must be shut down until the sludge can be thawed, and the pump started. Further procedure is the same as for usual starting up of machines.

GEORGE HOLMAN

Answer No. 178

George Suggests a Little Experiment

TO DRAW an analogy one might liken the brine pump in the refrigerating system to the fuel pump in a steam system. Stop the fuel pump, the steam immediately drops and will continue to do so until atmospheric pressure has been reached assuming the stop valve remains open.



Temperature and pressure relation of saturated ammonia at low pressures. Pressures are in pounds per square inch and inches of mercury absolute; vacuums are in inches of mercury

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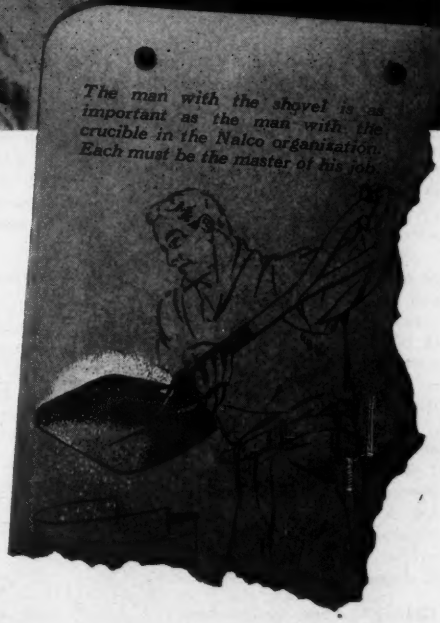
There are no cut and dried methods of water treatment that will best meet all requirements. To secure the maximum operating efficiency of your plant, you need the exhaustive analysis of your individual situation that Nalco research men can give you. It costs you nothing to have a Nalco Survey made of your plant — it may pay you rich dividends. Write to Nalco today.


The man with the shovel is as important as the man with the crucible in the Nalco organization. Each must be the master of his job.

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The Complete Water Treating Service **Nalco**

However, in the refrigerating system we have a prime mover still in operation in the form of the compressor. This unit will continue to pump or draw the vapor, containing heat, from the evaporator and will compress this vapor to compression heat.

By reason of the heat still being given up to the condensing water, the liquid will again be returned to the evaporator at approximately the same temperature as before.

Now, as heat is no longer being conveyed to the evaporator by the brine then the only source of heat for evaporation must come from the brine confined in the evaporator and from the total heat of the ammonia.

As the compressor continues to remove the vapor containing the heat which is transferred to the circulating water, the pressure in the evaporator will continue to drop with a corresponding drop in temperature. This temperature will drop until at a vacuum of between 14 and 15 in. we get a temperature of about minus 50 deg. F. with ammonia.

The brine in the evaporator by this time will be frozen solid unless of an unusual density. If the compressor is allowed to continue in operation the evaporator may be pumped down to a vacuum of somewhat below 20 in. or lower at which point the temperature will have reached minus 65 deg. F., the result of which can be imagined.

As a simple demonstration in heat transfer in relation to boiling points at different pressures I suggest that J. K. take a clear glass bottle and half fill it with hot water as near boiling as possible. Place the stopper or cork tightly in the bottle and allow cold water to run over it for a few seconds, observe the water immediately begin to boil.

Shut off the cold water for a minute or so then again apply for a few seconds and note the boiling again. This can be repeated until the water in the bottle is colder than the hand and yet will continue to boil. The boiling, of course, is due to the reduction of pressure on the surface.

For this reason ammonia (NH_3) at atmospheric pressure can't be retained as a liquid but evaporates into a gas at minus 28 deg. F. Corresponding boiling points at various pressures can be obtained from the ammonia tables, which every engineer should have on hand.

Kearney, N. J. GEORGE MCNALLY

Charley Says Stop the Compressor and Use Hot Water Gingerly

THIS IS what is sure to happen, and has happened time and again, if the brine pump stops and ice machine keeps running. You may regulate the suction pressure (back pressure) by hand or by a regulator, but the same thing will happen.

Brine passes from the pump through a cooler, usually consisting of a round shell, with perhaps 20 or more tubes in it. The heads of the shell are usually cast with deflectors or baffles so that the brine will pass any number of times back and forth. The shell outside of tubes contains liquid ammonia half way up, or perhaps a little more. The brine after passing through the cooler goes into the cooling coils and back to brine tank.

Suppose the pump stops, whatever brine is in the cooler will stop there. The ice machine is still running, so the brine temperature in the cooler will go down to perhaps zero temperature or to the freezing point which depends on the density of the brine. Inasmuch as J. K. did not state the density or temperature of the brine nor the suction pressure, exact figures cannot be given.

Now if the brine pump is started look at the pressure gage on pump and it will be found that the pressure is higher than under ordinary conditions. Also look at the brine return pipe in the brine tank and it will be found that no brine is returning (providing the brine in the cooling coils has had time to drain off). You can never pump brine through ice.

The first thing to do when you discover that the pump is down is to shut down the ice machine, even before you make an attempt to start the pump. Start the pump and if no brine goes through the system, take the insulation or covering off the cooler, play hot water, say 120-140 deg., on the shell, once in a while try the pump and see if brine comes back to brine tank, the gage will also tell.

It is really a simple matter to prevent this from happening. You may put in an electric device which will shut down the ice machine if pressure gets below a certain point, or put in a device connected to a bell transformer or batteries which will ring a bell in some place where someone will hear it any time.

Ogunquit, Me. CHARLES MAGNUS

Advises Using an Automatic Alarm

IF THE brine pump stops and the ice machine keeps runing, the brine cooler will freezeup quickly if you have a very weak solution of calcium chloride. If you have a strong or rich solution the cooler will still freezeup, but not as quickly.

If you are having trouble with the pump kicking out, probably the pump is not large enough for the work or there is a loose wire or a faulty unit in the control box.

I would advise putting in a temperature control solenoid coil, hooked up with a bell signal, but not on the same power line going to the motor pump. Then if a fuse is blown on the brine pump it will not interfere with the signal.

The control will work as follows: When the brine pump stops the brine temperature will start dropping. When it gets down to the set temperature it will automatically kick on the solenoid coil and ring the bell near you, warning you that the brine pump is off. It can also arranged to stop the compressor at the same time.

New Orleans, La. GEORGE DEICKMANN

Answer No. 179

Steam Valves for Ammonia?

J.K.R. needs some ammonia pipe and fittings, but is having trouble buying anything. He has, however, some small extra heavy steam pipe and fittings on hand. On p. 78 of the June issue he asked whether he would be safe in using these for ammonia.

Martin Says Go Ahead and Use It

THIS question fails to show any definite size of pipe, however, extra strong, or extra heavy pipe is the generally accepted pipe for connecting the various parts of the refrigerating system. Wrought-iron pipe, as a rule, is generally preferred to steel. Frequently a special weight or grade of pipe is used, for the evaporating or low-pressure side of the system. Standard and common pipe is sometimes employed for this.

When in doubt, under a particular set of conditions, and where the relative value of the material or manner in which the pipe is made, it is always better to use the standard extra strong grade.

Brass pipe should not be used, nor fittings of brass and copper content applied in ammonia practice, due to the corrosive action of ammonia on brass.

Threads for ammonia piping should be carefully cut with a good sharp die, making sure that the top and bottom of the threads are sharp and true. With a good thread in the fitting, it is not difficult in forming a good tight joint. Litharge or any suitable compound cement for ammonia joints may be used to insure no leakage in making up lengths.

When making up a pipe joint, make sure the pipe screws into the fitting the proper distance to form a contact the entire length, rather than to screw up against a shoulder without a perfect fit in the thread. This latter operation will show leaky joints sometime after the plant is in operation. The explanation to this is that the temporary joint formed either by screwing the pipe too deep against the shoulder, or by bad fitting threads, very often pass the preliminary test and will hold up for a time, until the alternate effects of heat and cold, and the chemical action of the ammonia cause it to break out and leak.

No amount of solder or doctoring that is not backed up by a good fitting thread to support it can make a good ammonia joint. This is particularly notable in the discharge or compression side.

I would suggest that J.K.R. get some regular ammonia valves, because they are of special make and construction, being steel or semi-steel, with a soft metal seat which may be renewed when worn and metal gaskets between the bonnet and flanges. If steam valves are used, the same trouble will be experienced as in the case of brass or copper pipe, by the action of the ammonia on the brass alloy valves, which soon will call for a shut down of the plant.

MARTIN N. GOZDENOVICH

Fairview, N. J.

THEY'RE TOUGH . . . THESE 125 lb. GATE VALVES

And they're proving it in countless plants in all industries. The extra strength built into these tough bronze valves comes in good stead in meeting the severe demands of continuous operation. Now more than ever they are proving to their users that it pays in the end to buy good valves first.

Figs. 2125 and 2129 are outstanding examples of the ruggedness and dependability that are inherent qualities in all Lunkenheimer products.

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Since virtually all materials used in the manufacture of valves are on the list of critical materials, valve users are urged to furnish the highest possible preference ratings and proper "end use" Allocation Classification Symbols on their orders. This will be of mutual helpfulness.

LUNKENHEIMER VALVES

Watch the Valves More Carefully

YES, you can use extra heavy black iron pipe for ammonia, but fittings should preferably be of malleable iron. I built a system (or rather a part of a system) over 20 yr. ago. I ran it for 6 yr. and as far as I know it is still running. This place was 100 mi. from the nearest supply house. I put in all malleable fittings that I could get hold of, but I also used some cast iron fittings. Of course in using cast iron you have to be careful not to set up too hard or they are liable to crack. I would not use galvanized or brass fittings and I would use as small an iron valve as possible, bearing in mind that expansion valves have but a very small opening.

Ogunquit, Maine — CHARLES MAGNUS

More on Use of Valves

ON STEAM valves for ammonia? I want to say that this is out of the question. It takes a lead seat to hold ammonia, and besides this caustic refrigerant will attack the common types of low-pressure brass or bronze valve trim. The heavy duty pipe is quite acceptable for use in refrigerating systems. But other fittings, tees, ells, etc., are acceptable only if they are of steel or malleable iron. Cast iron fittings are unacceptable for use in refrigeration systems.

Menard, Ill. — GEORGE HOLMAN

Letters And Comments

A Missourian Returns—Temporarily

J. C. DE FOE, frequent contributor to the P. E. & E. and a native Missourian who for the past few years has been exiled in the wilds of Kansas, with the oil wells and Indians, recently returned to his native state. For the duration he will be employed by Uncle Sam. He is now First Lieutenant, Co. D, 31st ET., temporarily stationed at Fort Leonard Wood, Mo.

The First Was Serious; the Captain Most Discreet

ON PAGE 85 in the March issue there appears an article on Bagging a Sub the Modern Way. A discussion arose within our department as to whether this article was intended to be humorous or serious. We would appreciate your advising us if the Army Captain was indiscreet or facetious and if the description of the rising of the sub is inaccurate, purposely or otherwise. E. F. P.

Quick Starting Turbines

REFERRING to the article on quick starting steam turbines, in the June issue p. 53, readers may be interested to know that about the year 1928, when the writer was associated with the firm of Stone & Webster, that two quick starting machines were installed in the Long Beach plant of the Southern California Edison Co.

These turbines would come up to speed (1500 r.p.m.) from a stand still and carry their full load of 2500 kw. in not to exceed 11 sec. which was considered rather fast at that time.

They could be started manually by remote control from the switchboard and they would start automatically upon loss of station auxiliary power and as there were no preliminaries they were always ready to start at a moments notice.

Jefferson City, Tenn. — E. WOODBURY

EDITOR'S NOTE: *A 4000-kw. turbine installed later in this same station is shown and discussed in an article Quick Starting Turbines by J. T. Moffett of the General Electric Co. on page 93 of the May, 1940 issue. From a cold start these turbines will attain full speed and full voltage ready for load in 15 sec. Governing and control for both quick start or spinning operation is discussed in the article.*

Steam plants operating in parallel with, and acting as standby to hydro plants with long transmission lines, as in California, are now commonly designed to pick up load quickly. The Burbank and Glendale municipal plants (see California Goes Modern, p. 52, September, 1940) are examples of this.

The Glendale plant, for instance, is designed to increase from 5 per cent to full load in 30 sec. During light loads the boilers operate at 725 lb. instead of the normal 600 lb. so that the accumulator effect will carry the load until the fans and burners get into operation. The new Los Angeles municipal plant now under construction is understood to be designed with the same end in view.

The Stooge Still Gripes—But What Happened to Pete?

DEAREST EDDY:—

Seeing as how it's been an awful long time since I heckled you, on account of because I'm busy winning the war, I thought maybe you'd like to hear about what I've been having happen to me. I got a promotion at the power plant. I am now third assistant to the Sweeper-Upper-in-Chief. I got the job on account of the U. S. Collection Service drafted the 3rd, 4th, 5th, and 6th assistants and they moved me up. Only they ain't hired a new 4th assistant for me to be over yet.

I got a uniform and a button with my pitcher on it what looks just like me only funnier. You have to wear your pitcher button so you can get past the she-cop what guards the plant. Honest, I ain't fooling. We got she-cops all over the place. Not only have we got she-cops, but she-timekeepers and she-button-pushers on the operating floor.

They is hiring a lot of she-help these days. Once I saw a pitcher in a power magazine what showed a swell looking dame in one of them movie dresses walking through the ash cellar of a powerhouse. It was supposed to advertise how clean the place was so that classy looking dames wouldn't be afraid to walk around in them long skirts. I thinks to myself at that time that this was maybe laying it on pretty thick, but now I don't know. She-help all over the place! Nerts.

Maybe you remember the good old days when you could walk down the firing aisle and see a whole lot of husky bohunks, stripped to the waist and shoveling like the dickens. Just suppose—well, I was only thinking.

It's terrible, Eddy. I would get me a job as kernel, or maybe even first class private, in the army if they didn't need me so bad to help make electricity. You know electricity is awful important. Just think what would happen if some of those Japansey bommers came over some night and there wasn't any lights to turn out for a blackout.

Anyhow, I got a brand new second hand uniform with four stars on the left shoulder. The boss says that if his wife gives him another bottle of brandy come next birthday, I can have four for my right shoulder too. Well Eddy, I must close now as that she-cop is snooping around again and will make me get away from the she-timekeeper's typewriter. Hoping the Collection Service don't get you, I am

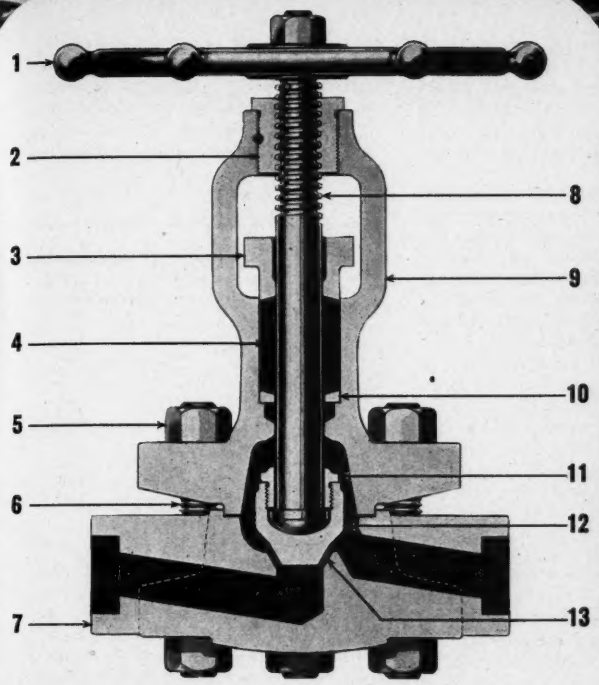
Your affectionate anti-she-helper.

PULVERIZER PETE'S EX-STOOGE

Anyway He Gets a Clean Shirt

TO THE average operating engineer, in the smaller power plants, the theory and technical part of engineering as applied to his particular plant, is like the foam on his beer, of no use and to be disposed of with a puff. Yet today, more than ever, a practical working knowledge, gained by long years of experience, can save many a dollar, and many headaches on the part of the engineer as well as the owner.

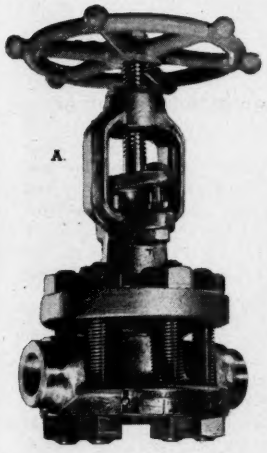
In the large plants, with the latest regulating and controlling devices, the operating engineer's mechanical ingenuity for saving in fuel, time, and labor, becomes dulled. As a consequence, if and when, he has to think up some makeshift to get by with, he's as helpless as a whale on the Arizona desert.



13 UNIQUE DESIGN FEATURES

Cut Operating Interruptions

LENGTHEN USEFUL VALVE LIFE



A.

1. Handwheel—malleable iron, oversize and knobbed for easy operation.
2. Yoke bushing—cast bronze, replaceable. Extra length threading minimizes wear, prevents galling.
3. Gland—drop forged steel, through bolted, accurately guided.
4. Packing—braided asbestos, wire inserted jacket with plastic core.
5. Bonnet nuts—easily accessible ASA heavy nuts.
6. Bonnet studs—fully threaded, air cooled, equal length for evenly-stressed tight bonnet joint.
7. Body—forged carbon-molybdenum steel (cast for 2 in. Fig. 5264). Metal distribution equalized to make distortion in heating and cooling negligible.
8. Stem—heat treated and ground EValloy (stainless steel).
9. Bonnet—carbon-molybdenum steel. Deep stuffing box and cooling chamber prolong packing life.
10. Junk ring—hardened, accurately gaged and fitted.
11. Disk nut—finely finished heat treated stainless steel. Pressure tight joint permits leakproof backseating.
12. Disk—alloy steel with heavy layer of ground and lapped Stellite on wide contact face. Balanced symmetry and correct clearances prevent wear in service.
13. Seat—continuous ring of Stellite, integral with body. Perfect alignment with working parts.

B.

A. Ready for hard work. Edward Intex globe stop valve Fig. 2264, socket ends, for 1500 lb, 950 F service. Note simple, sturdy construction.

B. No special tools needed for disassembly. Screw driver in slotted stem square makes it easy to assemble or remove stem and disk assembly.

C.

C. Wear-resisting Stellite seat is part of body in Intex valves. This means greater protection against corrosion and erosion, fewer interruptions, less maintenance, longer life.

EXTRA PROTECTION against costly operating interruptions, easier maintenance, extra life, and greater fitness for tough service are built into Edward Intex* valves in 13 different ways.

From the integral Stellite seat, which forever eliminates the possibility of leakage between the seat and body under high operating temperatures, to the easy-to-operate handwheel, every one of the 13 principal parts of Edward Intex valves have been designed for maximum operating efficiency under severe service conditions.

Like the integral seat, the contact face of the perfectly proportioned disk is generously faced with erosion-resisting Stellite. Valve ports are designed to give the least possible resistance to flow consistent with quick, positive cut-off.

Maintenance, though seldom necessary, is unusually simple. No special tools are needed for disassembly, and working parts are easily accessible.

Available in socket welding, screwed or flanged ends from ½ to 2 in., Intex valves are rated at 1500 lb sp at 950 F, but are equally trouble-free and economical in intermediate service.

*Reg. U.S. Patent Office.

Bulletin No. 12-G5 describes in detail the advantages of the smaller size Edward Intex valves. Full dimensional data, illustrations and material specifications. Write for your copy today!

THE EDWARD VALVE & MFG. CO., INC.

220 West 144th Street, East Chicago, Ind.

EDWARD *Steel* CAST AND FORGED VALVES

It's in the small isolated plants, where forced economy, lack of foresight, or what have you, on the part of engineer or owner, the old time engineer, who has been thrown on his own and had to make use of anything handy to keep the wheels turning, comes into his own.

Several weeks ago I dropped into a laundry office to get my shirts. As soon as I entered the owner dropped the phone he was frantically trying to get someone on, and rushing over greeted me like a long lost brother, gasping out that they were in trouble, and would I help him out.

Leading me into the boiler room he explained that the only source of boiler feed, a small duplex pump, had a couple of piston rings broken, and the local shop people could not supply new ones for a couple of days, and they had no spares.

Taking the broken rings from the engineer, fireman, etc., I asked if he had any ½-in. square duck packing. Dumbly nodding an affirmative, I told him to bring it pronto. Chucking my coat, I cut two rings of the duck packing and forcing them into the piston grooves, told them to replace the piston, put on the head and let her go.

Muttering and shaking their heads doubtfully they did and the engineer, etc., grinning sarcastically, turned on the steam watching for something to happen. To their surprise the pump buckled down and began to do business at the same old stand.

I dropped in there the other day. They have the new rings, hanging on a nail. The engineer explained that as the pump was doing all right they didn't bother to put the new rings in.

I contend that any man can do good work with good tools and materials, but the fellow that shines is the one that can take what he has at hand and keep the wheels rolling.

Wilkes-Barre, Pa. THOMAS M. STREET

Why Not Build Your Own Cylinder Truck?

MAY I add a note or two to the article by W. R. Linden in the Hints and Kinks section on p. 90 of the April issue. The work and experience related are my own and I believe the ideas are valuable to anyone planning to take Mr. Linden's advice for I have had the doubtful pleasure of mule-hauling a very similar rig over many weary miles of variegated surfaces.

The one point that can mean the difference between "She's a lifesaver", and "It's a man-killer", has been labeled, "Optional" on the sketch, and left unmentioned in the text. That point is the wheel diameter. Our truck was equipped with 10 in. wheels. The size pictured is similar, and similar results will be experienced. The center of gravity of the loaded truck is about 20 in. above the floor. The point of support is the axle, in this case 5 in. above the floor. The result is that when the assembly is tilted into the moving position, the center of gravity is not over the point of support, and part of the weight is carried by the operator. This alone is tiresome, but when the small wheels strike rough going, it becomes far worse.

A larger pair of wheels helps both of these difficulties considerably, and does not introduce any undesirable factors. The pair our truck was rehabilitated with were 26 in. in diam., through necessity, not by calculations. We now travel over rough ground, soft dirt and coal, "with the greatest of ease".

The wheels were made by separating into its two sections an old fabricated steel pulley, originally 26 in. in diam., and 3½ in. wide. When split it made two rather light rims with six spokes and a split hub. By welding, we added a hub, a band-iron tire, and a disc to close the open side of the wheels. The construction was not economical, but was our only recourse.

Another feature is the use of a wing nut and screw on the tie chains to hold the cylinders tightly.

We always stowed the hose by coiling it around the handle, leaving the torch attached and lying on the hose. One day when pulling the truck back from a job, the torch slipped off and passed under the wheels, breaking all three tubes. So a set of clips or other holding device for the torch may also be considered a worthwhile feature.

Devon, Conn. R. L. WILLIAMS

More on pH Values

ON PAGE 84 of the June issue, Sam Williams' letter on pH seems to have overlooked the gram molecular weights (Mol.) of the hydrogen ion and the hydroxyl ion. In his table he shows grams per liter which should have been mols per liter. As the hydrogen ion (H^+) shows a weight of 1 gram per liter, the hydroxyl ion (OH^-) would have to show a weight of 17 grams per liter because the hydroxyl ion consists of one atom of hydrogen, with an atomic weight of 1.0078, and an atom of oxygen with an atomic weight of 16. This totals 17 for the mol weight of the hydroxyl ion (OH^-) as the atomic weight of 1 for hydrogen is standard.

His table may be corrected by multiplying the right hand column, that is the 'grams OH^- per liter' by 17, or, he may leave the figures of the table as they are and call them mols instead of grams. The acidity of water is due to the positive charged hydrogen ions and the alkalinity is due to the negatively charged hydroxyl ions. At a pH of 0.0 there is 1 mol of hydrogen ions (H^+) and 0.000,000,000,000,01 mol of hydroxyl ions (OH^-) per liter.

If you wish to express this in grams you would have 1.0 grams of hydrogen ions (H^+) and 0.000,000,000,000,17 grams of the hydroxyl ions (OH^-). As you progress down the basic scale until you have a solution of maximum alkalinity you would have 0.000,000,000,000,01 mol of the hydrogen ion (H^+) and 1 mol of the hydroxyl ion (OH^-). This, expressed in grams, would be 0.000,000,000,000,01 grams of hydrogen ion (H^+) and 17 grams of hydroxyl ion (OH^-) with a pH of 14. The following table is very simple and one doesn't become dizzy looking at the decimal points.

Character	pH	Concentration of Hydrogen Ion (H^+) Mols per Liter	Concentration of Hydrogen Ion (OH^-) Mols per Liter
Acidic	0	$1 = 10^0$	10^{-14}
Acidic	1	10^{-1}	10^{-13}
Acidic	2	10^{-2}	10^{-12}
Acidic	3	10^{-3}	10^{-11}
Acidic	4	10^{-4}	10^{-10}
Acidic	5	10^{-5}	10^{-9}
Acidic	6	10^{-6}	10^{-8}
Neutral	7	10^{-7}	10^{-7}
Basic	8	10^{-8}	10^{-6}
Basic	9	10^{-9}	10^{-5}
Basic	10	10^{-10}	10^{-4}
Basic	11	10^{-11}	10^{-3}
Basic	12	10^{-12}	10^{-2}
Basic	13	10^{-13}	10^{-1}
Basic	14	10^{-14}	$1 = 10^0$

The pH value is equal to the logarithm of the reciprocal of the hydrogen ion concentration. Thus $pH = \log_{10} 1/CH$, where CH is equal to the hydrogen concentration. Thus at the neutral point, the concentration is 0.000,000,1, the reciprocal of this is 10,000,000 and the log is 7.

Columbus, O. GLENN BROWNING

Manpower in Modernized Plants

WHEN READING of new plants and modernization programs, there are two points which are never mentioned but which I often wonder about. Both of these I believe deserve attention in future articles or as topics for discussion in this section.

Frequently articles on modernization projects discuss in considerable detail the lessening of manpower of the new over the old. What becomes of these men who are replaced or let go? It seems to me that this is as important an aspect of modernization as any other, for it gives me a kindlier feeling toward the company if I know that they are not let out entirely.

It is possible, of course, that even though there is a great saving in labor, no men are actually replaced. These new plants are usually larger than the old ones so that while the labor per unit output may be decreased materially, the total labor is not reduced and, in fact, may be increased.

Another point never mentioned is the co-operation between the operating department and the designing engineer of the new station and whether or not the operating force, or at least the key men of the new operating force, are permitted to be in and around the plant while it is being built.

It seems important to me that every man in a new plant be allowed to watch and, if possible, take part in the start, construction and initial operation of a new power plant. I believe a man is better for it and certainly is more valuable to the company if this were done.

Lansing, Mich. ARTHUR F. CHURCHILL

FEEDWATER DEAERATION -

..A Modest but Important Factor in Curtiss War Plane Production

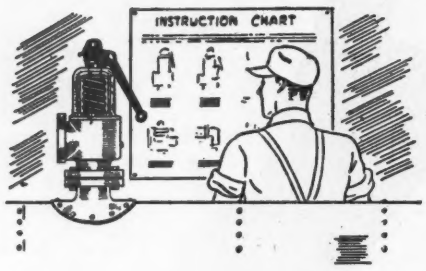
The great Curtiss Warhawk, latest of the P-40 type fighters swarming in ever increasing numbers over the battlefields of the world, is a tribute not only to the design but to the production genius of the Curtiss-Wright plants.

Cochrane has been privileged to contribute to this achievement by supplying several of the Curtiss-Wright plants with Cochrane Metering Deaerators of cast iron, caulked joint design and construction, the deaerating section mounted on a metering tank of similar design. The V-notch weir meter is electrically connected with a remotely located Cochrane Flow Meter Recorder.

COCHRANE CORPORATION
3123 N. 17th St., Philadelphia, Pa.

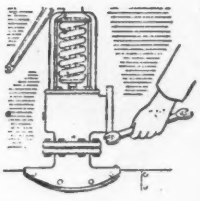
Cochrane

How To Make Your Relief and Safety Valves Last Longer



It should be remembered that a safety or relief valve is an automatic operating instrument and its proper operation is vital to the safety and welfare of the plant and personnel. Treat it as such and give it the best of attention

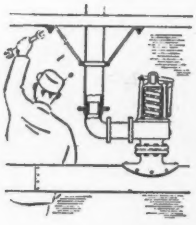
By W. J. H. MILLER, Manager
Consolidated Safety Valve Div.
Manning, Maxwell & Moore, Inc.



Installation

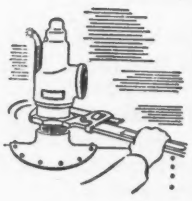
Mount the safety, or relief, valves as close as possible to the equipment they are protecting. Tighten bolts evenly in the valve flanges to eliminate all unnecessary strain in the valve body.

Piping between the vessel and the valve inlet tends to starve the valve with resultant chattering action. This will destroy the valves very quickly.



Discharge piping should be arranged so that no piping strain is imposed on the valve. Discharge elbows with a loose slip joint are usually installed for this purpose on steam safety valves while pipe bends or close anchoring to the vessel is the method most commonly used in the case of oil or gas safety and relief valves.

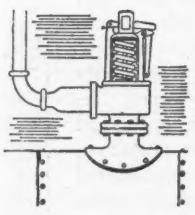
If connections are screwed, always use a wrench on the valve side of the pipe joint.



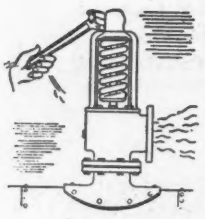
Do not swage the discharge piping to a smaller size. This practice puts back pressure on a valve which is not set with any allowance for back pressure in the outlet, and, results in increasing the wear on the valve seats.

Testing

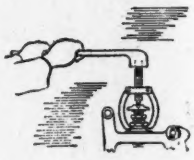
When installing valve, be sure dirt and grit have not accumulated in valve while waiting on the warehouse shelf or construction job. Use clean testing medium (clean air, or dry steam if possible) so that grease, dirt or foreign particles are not blown under the seat during the setting or testing of the valve.



Trip the valves with the lifting lever and hold it wide open for approximately 15 sec. This should be done while the boiler pressure is still approximately 20 per cent below the popping point of the lowest set valve. This may save trouble by blowing out foreign particles which could otherwise be caught between the seat and the disc during actual operation and thus be the cause of valve leakage.

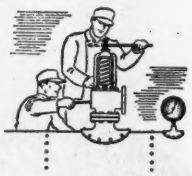


In using the test gag for hydrostatic testing of the valves, do not use excessive force on the gag. If ordinary tightening of the gag does not make the valve tight, mechanical difficulty is being encountered and force on the gag will damage the valve.



Setting

Set the valves to open as far as possible above the operating pressure of the equipment the valve is protecting. Be sure that the pressure gage with which the valve is set is correct (as well as the operating pressure gages) since a discrepancy can reduce the differential between the set pressure and the operating pressure of the equipment with increasing wear of valve seats.

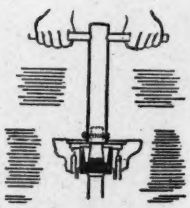


Do not set the valve with too little blowdown. We recommend 4 per cent with an absolute minimum of 3 per cent. Less blowdown than this will have a tendency to cause simmering and lead to increased corrosion of the valve seats.

Maintenance

Let one man handle all maintenance work on valves. We recommend that the valve manufacturer's repair procedure be followed closely. Ask for repair manuals and get the necessary maintenance tools.

Repair leaky valves at the first possible opportunity. Always use the lapping tools recommended by the valve manufacturer when doing maintenance work.



These tools have been determined to be the best and most economical for the repair of a valve and should be used, whenever such work is done.

When repairing valves, lap only the amount necessary to secure a tight valve. Overlapping wears away seat material and does not result in any improvement. Machining of parts should be unnecessary if valves are examined at regular intervals.

Use the proper seat and feather gages during the repair of all valves so that the critical dimensions in the operating mechanism of the valve will be maintained accurately.

Be sure the proper spring is in each valve and that in changing the original set pressure of a valve, the spring range is not exceeded. Always consult the manufacturer regarding contemplated changes in the set pressure of a valve.

A VITAL SERVICE

To Keep Power Drives Rolling at Peak Efficiency for Peak Production

Regardless of whether it is in your own plant, producing war materials, or on the machine you are building to turn out war materials, slip and waste in the transmission of power will cut down production. Morse representatives offer a vital service in helping you to prevent or eliminate these handicaps and thus boost production. Thoroughly trained in power transmission problems, they are able quickly to analyze, plan, or suggest installations of new drives or improvement of old drives. Let this vital service help you.

SILENT CHAINS ROLLER CHAINS FLEXIBLE COUPLINGS CLUTCHES

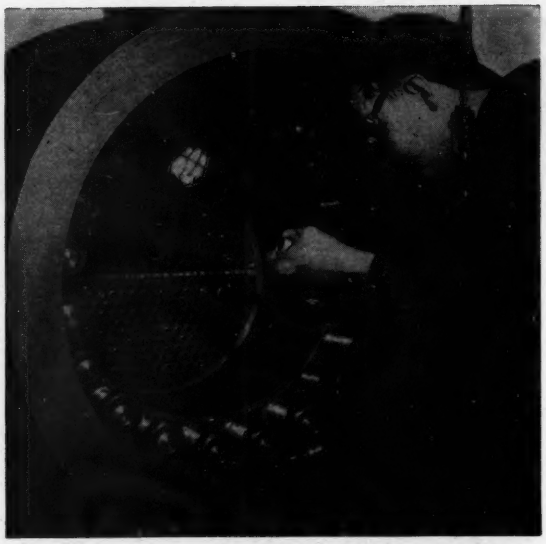
MORSE *positive* DRIVES

MORSE CHAIN COMPANY ITHACA N. Y. DIVISION BORG-WARNER CORP

SHOP TALK

A department showing by means of photographs how engineers in various plants have overcome certain obstacles or devised methods to facilitate operation. If you have done something along similar lines that you are proud of or which you feel may be of interest to others, send us a picture and a paragraph of explanation. If the photograph is good and if the idea is original we will present it on this page and pay you for it

UNIT HEATER. A Trane unit heater in a recent government plant. Note: the supports with turnbuckles for proper adjustment; the steam line with a scale pocket and an extension to the control valve for easy manipulation; and the scale pocket, valve and strainer in the drain line.



FOR 3200 LB. expanding Monel metal tubes in the head of a Foster Wheeler heat exchanger at the 2500 lb. Twin Branch Extension. The Monel metal tubes are ¾ in. O.D., No. 13 B.w.g. Two exchangers of this type are used, both designed for a maximum feedwater pressure of 3200 lb. and temperature of 492 deg. F. Tube bundles in both are alike, but the high pressure extraction heater has a desuperheating section while the cross over heater, designed for 700 lb., 650 deg. Fahrenheit steam, has not.

AIR COOLED. The introduction of air cooled, fireproof transformers with Class B insulation, in large sizes, solved many installation troubles. No special vault is needed because the oil hazard is eliminated, weights are low and temporary hookups easy because no fireproof vaults or catch basins for oil are needed. The photograph at the right shows a 300 kv-a. Westinghouse unit in the Union Potash & Chemical Mines near Carlsbad, N. Mex., where heavy layers of potash accumulate. As the work progresses the transformer is hauled to the new location to be set up.

SMOKE PATTERNS. The problem of introducing air into a room, without causing drafts or stratification, is a difficult one. These two photographs (left and below) taken by Barber-Coleman engineers in developing a diffuser for airplane cabins, show how the nozzle action of the original outlet was changed to a diffused air stream with their new special outlet. The difference is apparent.

YOU CAN'T GET A NEW BOILER OVERNIGHT

but you can increase the output of your present equipment without delay!

PERHAPS you may need new units to enable you to meet your peak demand. But it takes time to design, secure materials and erect new boilers —and time is short. So you are probably looking for ways and means of getting greater output from your present equipment.

One way of immediately improving your boiler operation is to use "Carbofrax"—the Carborundum Brand Silicon Carbide Super Refractory—in the clinker zone of the setting. Since "Carbofrax" brick do not soften at the high temperature encountered, clinkers do not build out on their hard dense face. Consequently, full grate capacity is assured and maximum steam production obtained. Moreover, eight to ten years of continued service is not unusual for "Carbofrax". And this longer life reduces refractory and labor costs, eliminates frequent and worrisome shutdowns for repairs due to lining failures.

Why not find out how "Carbofrax" can increase the efficiency of your boiler operation? We will be glad to assist you in making the application to your furnace. A letter or call to the nearest representative will bring a prompt response. A "Carbofrax" setting is a dependable setting.

CARBORUNDUM

THE CARBORUNDUM COMPANY, PERTH AMBOY, N. J.

REG. U. S. PAT. OFF.

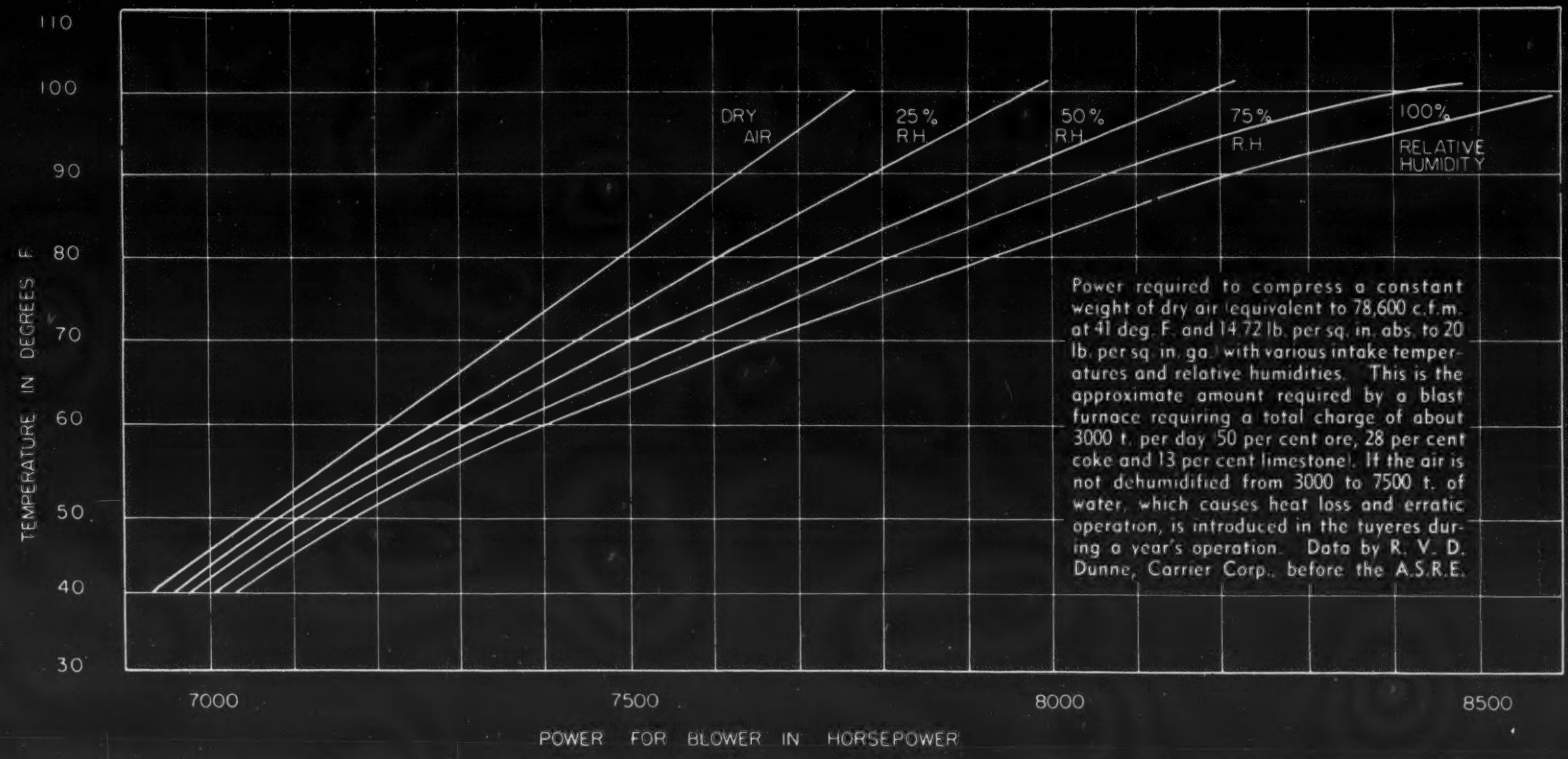
Refractory Division

District Sales Branches: Chicago, Philadelphia, Detroit, Cleveland, Boston, Pittsburgh. Distributors: McConnell Sales and Engineering Corporation, Birmingham, Ala.; Christy Firebrick Company, St. Louis, Mo.; Harrison & Company, Salt Lake City, Utah; Pacific Abrasive Supply Company, Los Angeles, San Francisco, Calif.; Denver Fire Clay Company, El Paso, Texas; Smith-Sharpe Company, Minneapolis, Minn.

(Carborundum and Carbofrax are registered trade-marks of and indicate manufacture by The Carborundum Company)

TEMPERATURE AND HUMIDITY CHANGE BLOWER POWER

Power requirements for industrial processes requiring a given quantity of dry air are materially influenced by temperature and humidity conditions. Water vapor compressed, with a given quantity of free air, varies almost directly with the relative humidity. In addition to the power loss this frequently interferes seriously with the process work. Thus in a blast furnace, water so added, reduces furnace capacity by absorbing heat during evaporation, and causes a trouble-some lack of uniformity. Frequently power savings at the blower (without considering improved process operation) more than pays for dehumidifying to reduce the moisture to a reasonable figure. For blast furnaces this is 1 to 3 gr.



Power required to compress a constant weight of dry air (equivalent to 78,600 c.f.m. at 41 deg. F. and 14.72 lb. per sq. in. abs. to 20 lb. per sq. in. ga.) with various intake temperatures and relative humidities. This is the approximate amount required by a blast furnace requiring a total charge of about 3000 t. per day (50 per cent ore, 28 per cent coke and 13 per cent limestone). If the air is not dehumidified from 3000 to 7500 t. of water, which causes heat loss and erratic operation, is introduced in the tuyeres during a year's operation. Data by R. V. D. Dunne, Carrier Corp., before the A.S.R.E.

★★★ GREAT TO FISH IN but UNFIT for Industrial Use

Surface waters cascading over rocks and lying quiescent in shaded pools offer an impelling lure to the angler. Even though crystal-clear, however, such water is practically never suitable in its natural state for steam generation, processing or other industrial needs.

Any water from river, deep well or other natural source requires study and treatment before use, to safeguard and prolong the life of boilers and other plant equipment operating under today's heavy demands. The Betz organization of engineers and chemists is trained and skilled in the conditioning of any water for any industrial use. For any plant, however large or small, Betz stands ready to render a complete water service—of consultation, research, design and supervision.

Write for complete information, giving details of your particular problems.

If you are interested in steam purity and its safeguarding by conductivity instruments, write for booklet describing the accurate, rugged low cost Betz Conducto-Bridge.

W. H. & L. D. BETZ

Consultants on ALL Water Problems

FRANKFORD • PHILADELPHIA • PENNSYLVANIA

LABORATORIES AND ENGINEERS LOCATED THROUGHOUT U. S. A. AND CANADA

A.I.E.E. Summer Convention Well Attended

THE SUMMER CONVENTION of the American Institute of Electrical Engineers held at the Drake Hotel in Chicago, June 22 to 26 was exceptionally well attended, the total registration being over 1100. Considering the pressure of the war effort on many of the members, together with the difficulty of travel these days, this attendance was ample justification for the decision on the part of the Institute to hold the convention. Some months ago there had been some thought of discontinuing some of the engineering conventions. The success of the recent Chicago meeting, however, seemed to prove that these meetings have a definite value in bringing together engineers from all parts of the country and bringing about an interchange of ideas that could not be achieved in any other way.

This was essentially an engineering meeting. There were practically five days of solid technical sessions. Social events were limited to a few evening events and inspection visits were confined to places which had little or no strategic war importance.

Few, except those of us who are more or less directly concerned with the generation and distribution of power, realize how important power is in carrying on the war effort or how well the power companies and the manufacturers of power equipment are doing their work in keeping an adequate supply of power flowing. Except for a few temporary shortages last year as a consequence of low water in certain areas, there has been no lack of power anywhere and no slowing up of the war effort due to lack of power. While the reserve generating capacity is not as great in some localities as might be desired, every effort is being made to guarantee an adequate power supply for all war industries no matter how rapid the growth in load.

This question was discussed at the meeting by two government spokesmen, J. E. Moore and E. Falck, both of the War Production Board. It was gratifying to know from the remarks of both of these men that the attitude of the W.P.B. is decidedly cooperative and that every effort is being made to let the power companies solve their own problems in their own way. The power problem they pointed out must be met on a regional basis. There is no country-wide power problem but the question of power demands study in all regions so that if power shortages tend to develop, proper steps can be taken to meet them before they materialize. This, naturally, requires the close cooperation of everybody involved—the government, the power companies and the manufacturers of equipment. It will be profitable for the men responsible for power plants to study closely the operating conditions that are likely to be imposed. Maintenance is going to be a vital problem.

A number of the papers presented at other sessions dealt with related aspects of this subject. There was an entire session devoted to the problem of overload operation of transformers and rotating machinery. These papers involved discussion of such things as deterioration of insulation under high temperature, methods of increasing the load capacity of oil-cooled transformers, etc. This session was unusually well attended, indicating the great interest of the members in this phase of the power problem. The operation of electrical machinery at overloads involves the problem of testing and it was pointed out in the discussion that such tests must be carefully devised. In one case mentioned, a 40,000 kv-a. transformer was completely destroyed by heat. The unit, however, was put through all the dielectric tests and was found to be perfect. This instance was cited to emphasize the need for caution in applying tests for specific purposes.

Among other aspects of transformer operation that were discussed in connection with this question of loading was that of paint. Aluminum paint is used on many outdoor transformer installations. Because of the high reflecting power of aluminum paint such units tend to run cooler in bright sunlight than units painted black. This does not hold true for units in the shade, however, and as pointed out by a speaker from San Francisco, it was his observation that a transformer painted black is often 6 to 8 deg. cooler in the shade than another similar unit painted with aluminum paint. In certain areas in California, he said, summer temperatures of 136 deg. in the sun and 114 deg. in the shade prevail. Under such conditions he believed it better to erect sun shades over transformer installations and paint the units black.

While questions such as these dealing with methods of operation excited much interest there was equal interest in the many new developments covered by many of the papers. The development of a new jewel for indicating instrument bearings, for example, was discussed with a great deal of interest by the instrument men because the supply of natural sapphires from Europe has been largely cut off. The new bearing is a hot pressed glass jewel developed at the General Electric Co., and, as described in a paper by F. K. McCune and J. H. Gross, it has practically all of the characteristics desirable in a sapphire bearing and can be produced in quantity at reasonable cost.

Another new device described was a 600-v. limiter for network use. As pointed out in a paper by J. M. Wallace of Westinghouse, this limiter in tests at the Westinghouse laboratories had disconnected as much as 54,000 kw. of momentary short circuit current.

A new moving magnet instrument for direct current described in a paper by H. T. Faus and J. R. MacIntyre, both of General Electric, was of interest because it marks one of the very few changes in direct current instrument principles since the D'Arsonval instruments were developed. While not as sensitive as the D'Arsonval instruments, the authors felt that this new instrument has inherently lower cost features and will withstand more abuse.

W.P.B. men at the A.I.E.E. Convention in Chicago Left to right, J. E. Moore, War Production Board; A. C. Montieth, Mgr., Westinghouse's Industry Engineering Dept.; W. L. Cisler and E. Falck, both of W.P.B.

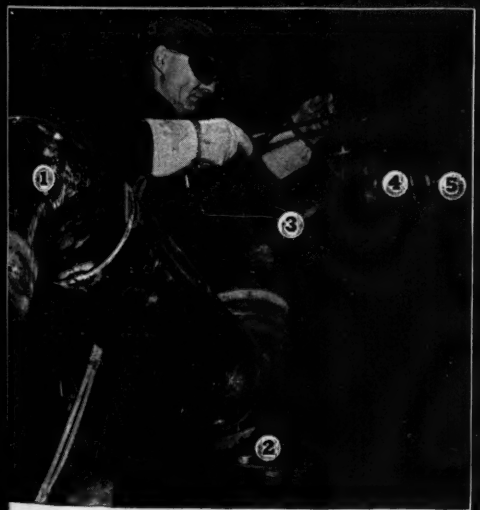
Lighting had its share of attention in a conference on lighting aids to wartime production. This conference included discussion not only of lighting systems but also the use of substitute material in the manufacture of industrial lighting equipment. Another conference was held on electronic control of resistance welding. This discussion was informal but was opened by two brief talks by G. W. Garman of General Electric and E. H. Vedder of Westinghouse.

Besides the topics mentioned, there were sessions on switching equipment, communication, lightning, protective relays, electronics and standards, power transmission and distribution, transportation, mercury arc rectifiers, cables, etc. In all, some 75 or 80 papers and conference presentations were involved.

Harold S. Osborne, Plant Engineer, Operation and Engineering Department of the A. T. & T. Co., was elected president of the Institute for the year beginning Aug. 1. The annual report of the Board of Directors, presented at the meeting, showed a total membership on April 30, 1942, of 18,944.

Tube-Turn Welding Fittings are built to *stand the gaff* at the turns!

FASTER INSTALLATION WITH TUBE-TURN WELDING FITTINGS



In the above assembly, Tube-Turn welding fittings are speeding up the erection schedule and permitting a compactness of piping impossible if handled any other way. Also, their uniform wall thickness makes aligning and welding quicker and easier. Note the five Tube-Turn fittings in this small piping section: (1) a 90° elbow; (2) a tee; (3) another 90° elbow; (4) a lap joint welding nipple; (5) a lap joint flange.

It's tough enough to hang on the board when a speed boat is making sharp turns along a zig-zag course, but add the perilous sport of water jousting—and the *danger at the turns* is doubled!

Extra punishment occurs *at the turns* in industrial piping systems, too. That's why it is safer practice to *weld piping with Tube-Turn fittings.* Tube-Turn fittings provide maximum strength, prevent leakage permanently, and practically eliminate maintenance costs.

There's a Tube-Turn fitting for *every* pipe welding need—the right type, size and weight for every job. Insist on genuine Tube-Turn welding fittings for longer life in your piping.

Send for valuable data book and catalog.

Tube Turns, Inc., Louisville, Ky. *Branch offices:* New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Tulsa, Houston, Los Angeles, Washington, D. C. *Distributors in all principal cities.*

TUBE-TURN TRADE MARK

The FIRST WELDING FITTINGS 1ST AND STILL THE BEST

Welding Fittings

War News From the Industrial Front

Curb Lifted on Coal and Coke Inventories

CHEMICAL producers are permitted to bulid up inventories of coal and coke by Amendment No. 2 to Preference Rating Order P-89, issued late in June by the Director of Industry Operations. The action was taken as part of a Nation-wide drive to encourage the accumulation of fuel stocks in anticipation of shortages expected to be caused next winter by war demands on transportation facilities.

War Workers May Be Eligible for Tires

AN AMENDMENT to the tire rationing regulations that makes war workers eligible for third, fourth, and fifth line new tires under restrictive conditions, and, simultaneously provides a system designed to make each tire deliver the utmost in essential transportation was announced. The amendment was put into effect July 15.

An employee of an establishment essential to the war effort and employing more than 100 workers must present to his local War Price and Rationing Board a statement, from a committee set up in his own plant, showing that he needs tires and has agreed to make maximum use of them in carrying other employees to and from work.

Utility Company May Sell Excess Stocks

A UTILITY company may sell materials from excess stocks or inventories to any other utility company or war production plants, provided the order for such material carries a preference rating of A-5 or higher. This is provided for in Amendment No. 2 to P-46, announced July 9.

Calcium Hypochlorite Goes Under Allocation

TO INSURE adequate supplies of high test calcium hypochlorite and chloride of lime, commonly known as bleaching powder, for civilian defense gas decontamination and for essential uses of the Army and Navy, the entire supply was put under complete allocation control July 6 by the Director of Industry Operations.

Phosphate Plasticizers Placed Under Control

TO DIRECT available supplies of phosphate plasticizers into the manufacture of war-essential flame-proof cable, antifouling paint, airplane dopes, wire insulation, photographic film, and other plastics, the entire supply, production, and use of such plasticizers has been placed under complete allocation control by the Director of Industry Operations with General Preference Order M-183.

Ratings Extended on Power Equipment

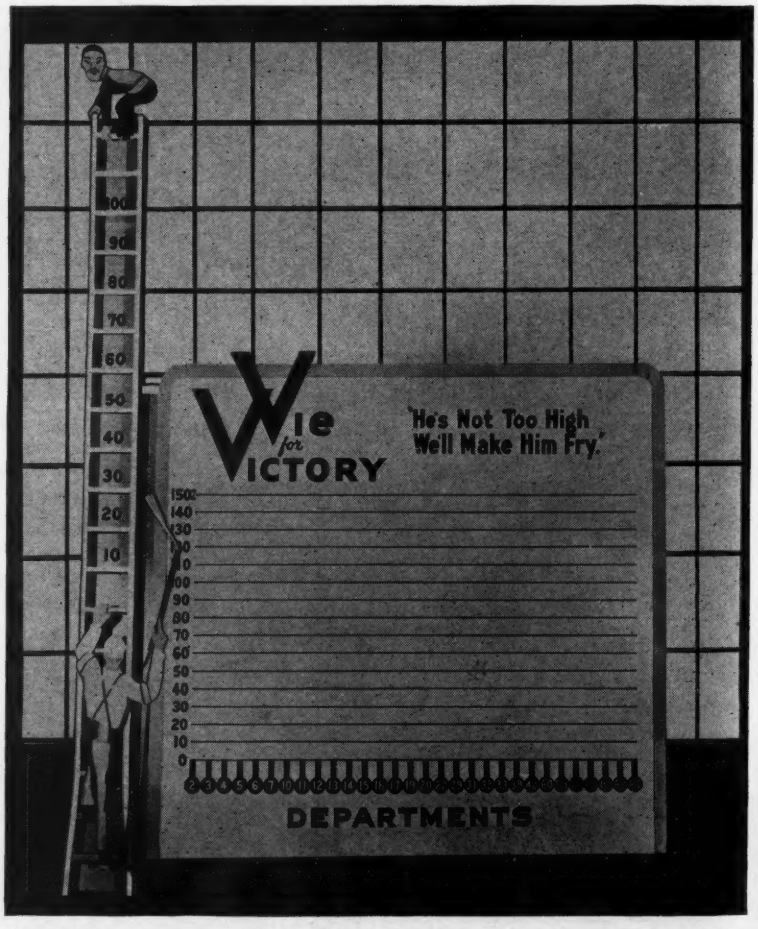
LIMITATION Order L-117 was amended the middle of last month so that contractors engaged in the construction of industrial plants may obtain delivery of heavy power and steam equipment to be used in such plants by extending preference rating certificates on orders issued to the persons for whom such plants are being constructed. Heretofore, Order L-117 permitted heavy power and steam equipment to be delivered only to the person to whom a preference rating certificate or order was originally issued.

To Help in Priority Tie-ups

A NEW SERVICE for applicants for priority assistance who use individual PD-1A certificates was announced in July by J. S. Knowlson, Director of Industry Operations of the WPB.

If applicants will enclose with their application blank a self-addressed post card, the case number assigned to their application will be stamped on the card, it will then be returned to them to facilitate handling of subsequent inquiries with respect to the application. All inquiries concerning applications should be submitted in writing.

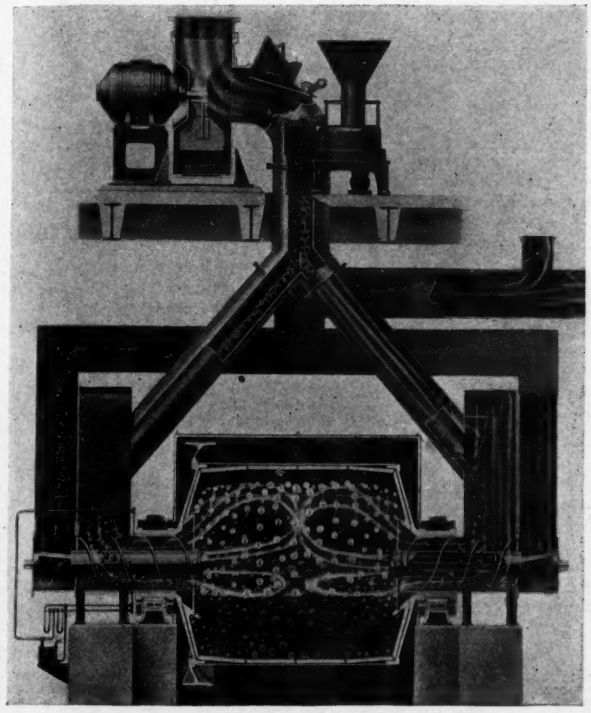
In order to avoid unnecessary correspondence, applicants are requested not to make inquiries concerning their cases for two weeks after they have been received by WPB. This is the maximum time normally required to process an application, and usually the application will either be granted or denied in a shorter time. If there is a delay beyond 2 wk. or if for any reason supplementary information is submitted, use of the case number in correspondence will expedite handling and assure a prompt reply.



Scoreboard used to record progress of Idea Contest to speed war production in the plant of Crocker-Wheeler Elec. Mfg. Co., at Ampere, N. J. As ideas are accepted, a cut-out figure of a workman carrying an acetylene torch progresses up 15 ft. ladder. The torch reaches the Jap when the full quota of ideas for entire plant is attained. Relative standings of individual departments are shown on board attached to ladder

FOSTER WHEELER PULVERIZER

MAKES HARD GRINDING EASY



Double Classifier Ball Mill

Relative effectiveness

of

HARDINGE TYPE BALL MILL

to other mills

increases directly with

Hardness of Fuel

This mill provides high availability without installation of multiple pulverizers per boiler. Typical performance records covering 25 pulverizers having 157 mill-years of service show an average availability of 99.3%. It naturally follows that where availability is high maintenance costs are low and such is the case with Foster Wheeler pulverized fuel systems. The maintenance cost per ton for these 25 mills was .0132 cents per ton for 7,363,000 tons of coal.

These advantages of the Hardinge type mill reflect in the frequency with which other makes of boilers are supplied with Foster Wheeler mills (134) and the infrequency with which Foster Wheeler steam generators (9) are equipped with other pulverizers.

Foster Wheeler Corporation, 165 Broadway, New York, N. Y.

FOSTER WHEELER

New Equipment

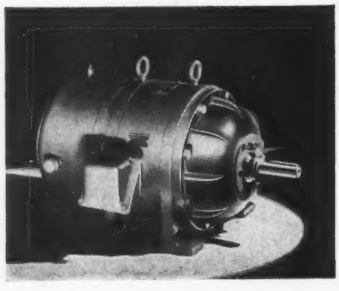
Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Soldering Flux

A NEW improved soldering flux is being produced by the Industrial Service Laboratories, 7656 W. Forest Home Ave., Milwaukee, Wis. Known as Special-X Industrial Concentrate, it can be used full strength or diluted, to suit the required job. The product is said to be extremely powerful, yet will not injure or discolor the base metal being soldered and may be easily usable on stainless steels, monel metal and alloy except aluminum.

Motors For Magnesium Dust Locations

A NEW LINE of polyphase induction motors in sizes from 1 to 20 hp. NEMA frames 203 to 326 inclusive, suitable for use under magnesium dust conditions has been recently announced by the General Electric Co., Schenectady, N. Y. Labeled as suitable for Class II, Group E locations, the new line should find extensive use in the rapidly growing number of plants handling magnesium, particularly where fine magnesium dust is encountered.



The new line has been developed to meet a need brought about by the extensive use of magnesium and aluminum in war production. In many cases, motors are being subjected to these metals in the form of fine powder, as used in incendiary bombs and for other military purposes, or from castings during grinding or polishing operations. Since these dusts are extremely combustible, they present a hazard classified by the National Electrical Code as Class II, Group E, requiring special motors and control.

The design of the new line of motors is based on a series of tests recently initiated by G.E. at the Underwriters' Laboratories, Inc., in which a sample 15-hp. 1800-r.p.m. motor was subjected to a cloud of fine magnesium dust while operating under heating and cooling cycles simulating several years' operation in an industrial plant. Careful examinations of the motor after these tests indicated that it had successfully withstood all tests.

These motors are totally enclosed, with a nonventilated construction in the smaller ratings and a fan-cooled construction above 2 hp. Simple cast-iron end shields, stator frames, and fan housings make possible dust-tightness without complicating assembly or disassembly.

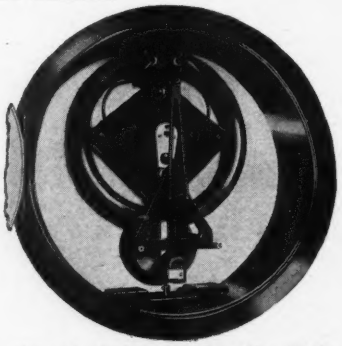
Other features of the new line include nonsparking bronze external fans, relatively straight and smooth external ventilating passages (for fan-cooled motors) to facilitate cleaning, permanently sealed-in leads, and a rotating labyrinth seal at the shaft opening.

Ultra High-Pressure Flow Meter

COCHRANE CORP., 17th St. & Allegheny, Philadelphia, Pa., recently announced a new ultra high-pressure flow meter.

In high-pressure process operations in the neighborhood of 5000 psi. flow measurement has been impracticable with mechanical head type meters and employing a stuffing box. Accuracy, freedom from maintenance, and complete safety are now secured by a special adaptation of the ring balance (tilting U-tube) which has no float, stuffing box, or pressure-tight bearing; being entirely closed and without internal working parts.

The mercury sealed manometer is a stainless steel ring 15 in. in diam. The ring is balanced on knife edges at its geometric center. Nickel tubing connects the top of the ring to the center of rotation where they join the free (inboard) ends of the twin 6-in. nickel torsion tubes. The outboard ends of the torsion tubes are anchored and to these the pressure lines from the primary elements are connected.

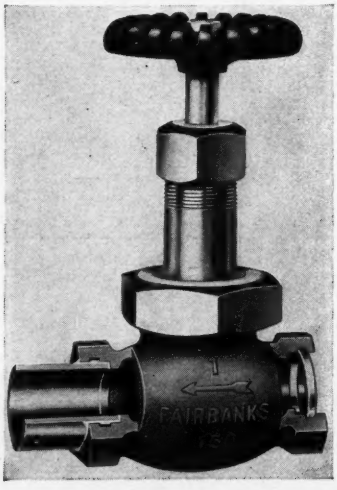


By this design the ring tilts 10 deg. for the full differential range measurement which may be between 4 and 9 in. of mercury depending on the cam weight supplied. The cam extracts the square root relationship so as to express the flow directly in uniform increments on the 36-in. indicating scale which may also be combined with an integrator and/or 12-in. recording chart feature.

The rugged construction combines every desirable detail such as ball bearing cam strap sheave, integral plumb bob and alinement scale, lens type metal gaskets, mid-scale calibrating pin so as to afford maximum dependability and operating convenience. These meters are said to be tested under 7500 psi. and are for use for measurement of nitrogen, hydrogen and ammonia gases at pressures above 5000 psi.

New All Purpose Valve

THE FAIRBANKS CO., New York, N. Y., recently introduced a line of Faircoseal bronze valves which contain pre-inserted rings of Sil-Fos silver brazing alloy in the port openings, instead of threads. With this design, valve and pipe can be easily brazed together into a one-piece piping assembly by the application of an oxy-acetylene flame. When valves are connected to brass, copper or copper-nickel pipe, a Silbraz joint is formed.



Silbraz joints are designed to withstand tensions, compression, torsion, vibration and corrosion to the same degree as the pipe or tube with which they are used. The Silbraz joints are silver brazed and not soldered joints and do not depend on wicking, solder or pipe dope to effect a water or gas-tight seal, as both pipe and valve are brazed together as one piece. With these bronze valves, copper, yellow or red brass, copper-nickel and Monel pipe can be used and the valves can be used with steam, oil, hot or cold water, compressed air, acid, Freon, sulphur dioxide, etc.

Axial-Flow Fan

A RADICAL innovation in axial-flow fan design has recently been announced by B. F. Sturtevant Co., Hyde Park, Boston, Mass. This new fan, which is known as the Victory Axiflo Fan, possesses outstanding features in perform-

THE Gilmer NATIONAL POWER-RECOVERY PLAN

". . . we are glad to express our appreciation of your efforts in this direction," says WPB

INDIVIDUAL POWER-RECOVERY ESTIMATORS MAKE POWER-SAVING SIMPLE AND SYSTEMATIC . . . . .

Developed to help Industry convert power-waste into war production, the Gilmer National Power-Recovery Plan provides useful Power-Recovery Estimators . . . practical power-saving charts for each of these services —Electricity, Steam, Mechanical Transmission, Water, Compressed Air, Refrigeration, Boilers, and Prime Movers.

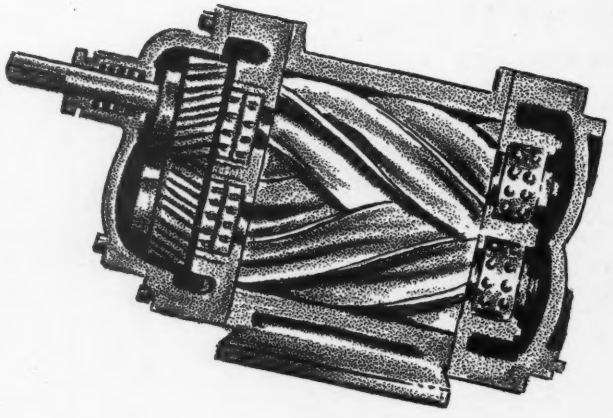
Compiled by leading power engineers, the Estimators are full of technically-sound suggestions, to help make power-saving a simple routine. In your hands, the Estimators cannot fail to produce results beneficial both to your plant and to your Country.

Take full advantage of the Power-Recovery Plan . . . use it to get the necessary executive support, then put it to work in your plant! Completely packaged in a special Booklet, it comes without cost or obligation. Write to Gilmer at once!

L. H. GILMER COMPANY • Tacony, Philadelphia, Pa.
The Oldest Firm of Rubber Fabric Belt Specialists

Authorities on power engineering estimate that, if Industry adopts the Power-Recovery Plan, the resultant power-saving will equal the combined output of two Boulder Dams!

Maintaining Pressure



against the Axis

MILITARY pressure of uninterrupted production is the responsibility of Quimby Rotex Pumps throughout America. Most efficient use of oil is one of the vital factors of this war. Quimby Pumps have had an unqualified reputation for half a century.

The positive, pulseless discharge and constant availability for service of Quimby Rotex Pumps have made them leaders in peace and indispensable for war.

THE BEST PUMP FOR THE JOB—
IS THE MOST ECONOMICAL PUMP TO USE!

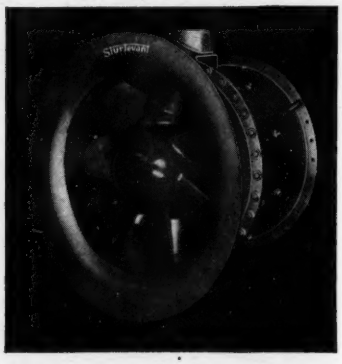
QUIMBY PUMP COMPANY, INC.
352 Thomas Street, Newark, N. J.

QUIMBY PUMPS

Better Pumping Practice
SINCE 1894

ance, quiet operation and savings in weight, space and power.

For the duration of the war the use of the fan must be restricted to the U. S. Navy, where it is now being used for heating, ventilating and mechanical draft service on battleships, cruisers, destroyers, and airplane carriers. At the conclusion of the emergency, it will be available to industry.



Among the outstanding features of this new fan are said to be, mechanical efficiency over 90 per cent; extremely quiet operation (a given unit produces only 80 decibels when supplying 12,000 c.f.m. at 3 in. static pressure); comparatively small size, light weight, compact; pressures range from ½ to 6 in. water gage for the motor-driven ventilating fan; other designs with turbine drive operate against pressures as high as 60 in. water gage; high rotative speeds (motor-driven units operate at speeds as high as 5000 r.p.m.).

Bearing Washer

DEVELOPED by lubrication engineers of the Croft organization and distributed by the Ahlberg Bearing Co., 3074 W. 47 St., Chicago, Ill., an adaptation of a production type bearing washer for industrial plant use has been developed by means of which bearings can be washed and thoroughly dried for periodical inspection and then repacked with fresh lubricant.

The unit is easily portable and has a sealed compartment to prevent evaporation loss of the solvent solution. Provision is made for a compressed air dryer which blows the bearing dry and clean, making the whole operation complete and easy in a minimum of time. The unit weighs 10 lb. and handles a full range of bearing sizes.

An additional unit for repacking the cleaned bearings with fresh grease is a second development. With the 5 lb. of clean lubricant in its base the bearing is placed on top of the unit and a lever forces the clean grease through the bearing without waste or muss and without danger of dirt and contamination being carried in the lubricant.

RUST CLOSING IN ON YOUR TURBINES?

DON'T wait for rust to stop your turbines. It's far less costly to drain, flush and refill with new Shell Turbo Oil. Act now! You'll find new, tested and service-proved Shell Turbo Oil meets all 3 requirements of modern turbine lubrication:

RUST PREVENTION
SUPERIOR OXIDATION STABILITY
MINIMUM FOAMING TENDENCY

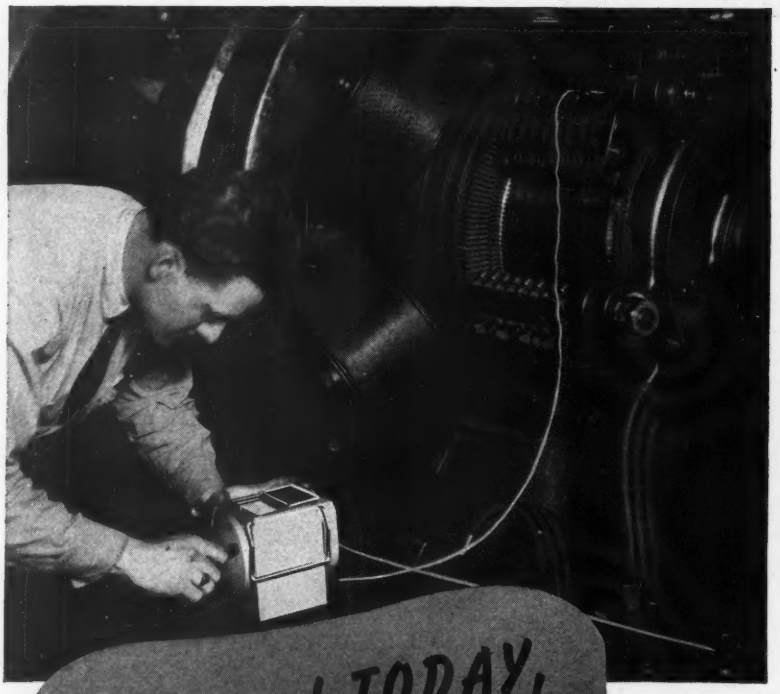
Don't accept less! Call in Shell now!

SHELL

Protect your turbines with RUST-PREVENTIVE

SHELL TURBO OIL

TAKE TIME TO TEST . . . *and* SAVE TIME



. . . and TODAY, TIME is priceless

Although "Megger" Insulation Testers have been used for years by industry to detect and forestall electrical breakdowns, their use today has assumed an importance out of all proportion to the cost of the instrument—or the amount of time spent in using it. It is not merely a matter of dollars and cents. Production time is priceless . . . and electrical equipment is most difficult to replace. *Minutes* with a "Megger" Tester can save *Days* of delay.

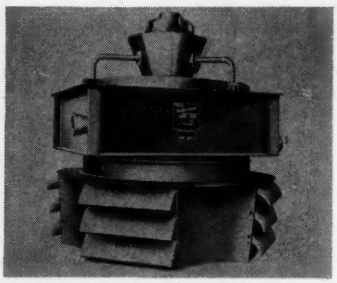
Under the stress of present demands, everyone who is directly or indirectly responsible for keeping motors, generators, wiring and other electrical equipment in good operating condition, should be fully acquainted with the advantages to be gained by the use of a "Megger" Tester. Write us for a free copy of the Pocket Manual of "Megger" Practice No. 1420-PE.

JAMES G. BIDDLE CO.
1211-13 ARCH STREET • PHILADELPHIA, PA.

"MEGGER"
TRADE MARK REGISTERED U.S. PAT. OFF.
Insulation Testers, Ground Testers and Ohmmeters

Revolving Unit Heaters

THE L. J. WING MFG. CO., New York, N. Y., announce an addition to their line of revolving unit heaters, with a new variable discharge heater. Provision for adjusting the amount of heated air discharged from any side of the heater is incorporated in the discharge outlet, making possible the heating of

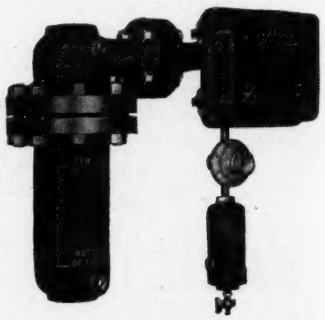


a long, narrow room or building with one revolving unit heater, the air streams being reduced and extended as the discharge outlets cover the sides and the ends respectively.

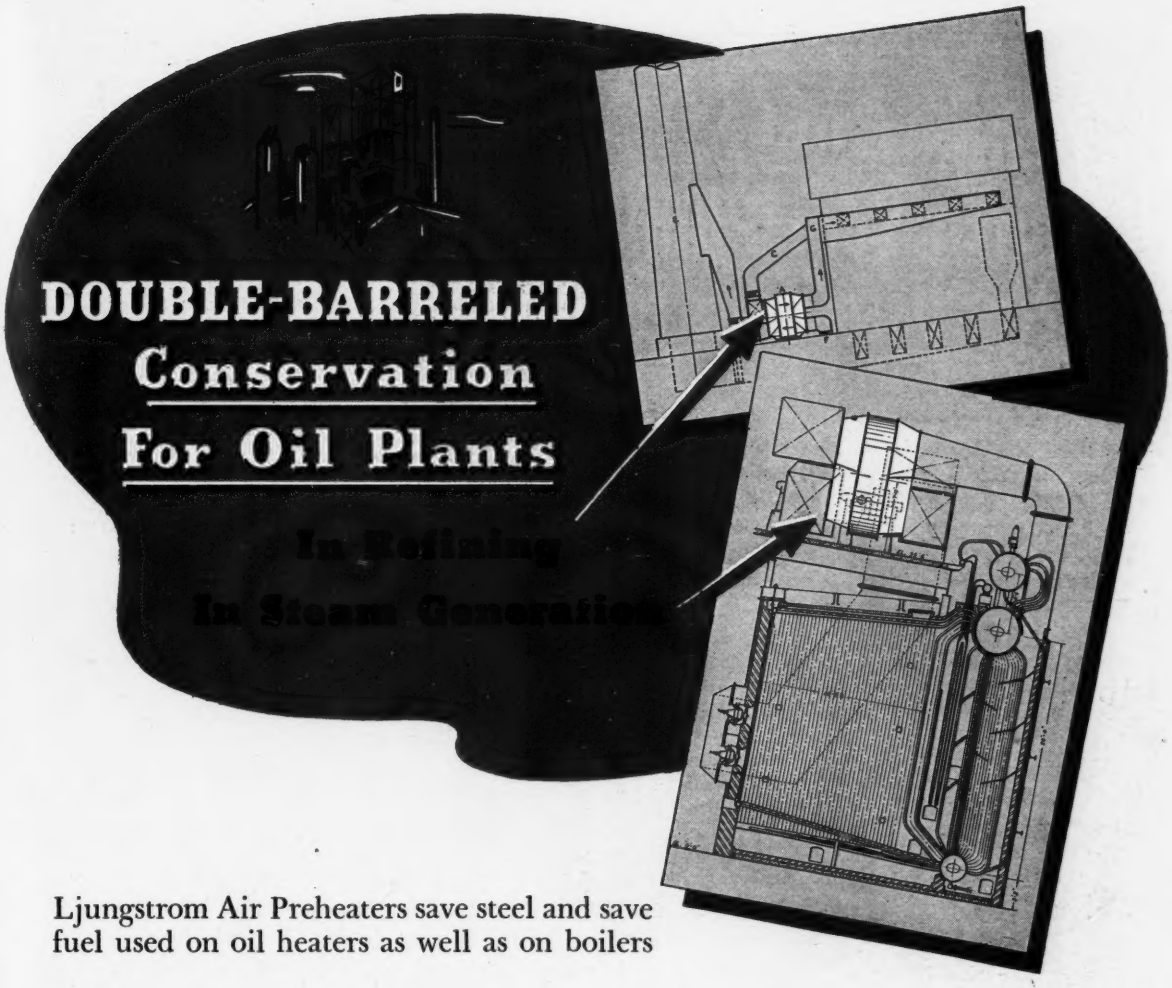
The discharge from the multiple outlets is said to be effective in buildings or rooms with low ceilings. The additional number of outlets break up the discharge into slower but more closely spaced streams of heated air which circulate around obstacles and reach cold corners, maintaining a uniform temperature and gentle movement of air throughout the entire building or room.

Displacement Type Level-Trol

THE FISHER GOVERNOR CO., Marshalltown, Ia., announces an improved displacement type Level-Trol that features greater sensitivity, speed of action, freedom from service trouble and ease of adjustment. It is available in float cage or internal float type construction for handling all liquids at all pressures, temperatures and specific gravities. Level-Trols can be used for level control, interface level control, level indication, or specific gravity control.



The pilot is 100 per cent pneumatic in operation with all linkage, pivot points and other sources of friction eliminated to reduce the operating power to an absolute minimum. Level position adjustment permits the positive controlling of level at any desired point within the length of the float while the throttling range adjustment makes it possible to vary the amount of level change nec-



Ljungstrom Air Preheaters save steel and save fuel used on oil heaters as well as on boilers

On oil-plant steam generating units, Ljungstrom Air Preheaters are fast becoming standard. Recent orders for steam generating plants of *three different oil companies* . . . being supplied by *three different boiler manufacturers* . . . all call for Ljungstroms.

There's a double-barreled reason for this preference: (1) The increasing need for fuel conservation, even where it is freely available at low cost, raises the importance of improved combustion and heat recovery obtained with preheated air. (2) The Ljungstrom Air Preheater gives more heat recovery per pound of steel. Frequently a Ljungstrom weighs only ½ to ⅓ as much as alternate types, with additional savings in the supporting structure.

On cracking still furnaces, too, preheated air does double duty for conservation: (1) It lowers fuel consumption, (2) It permits a significant reduction in the alloy steel convection tube banks. Exit gas temperatures from the furnace as high as 1400 deg. F. are practical with "high-temperature" Ljungstroms, heating combustion air to 1000 deg. F. or more. This means maximum heat recovery per pound of oil-tube steel.

A new illustrated booklet, "Another Kind Of Air Power With A Wartime Job To Do", tells how the Ljungstrom is being used in wartime service. Case history information of savings resulting from use of the Ljungstrom makes it worthwhile reading. It's yours for the asking. Write for a copy today.

THE

AIR PREHEATER
CORPORATION

Executive Offices: 60 East 42nd Street, New York, N. Y. • Plant: Wellsville, New York

DON'T DELAY!

Search Your Plant Today FOR USED DART UNIONS

...and Put Them Back to Work to Conserve Vital Metals

The search is on—in plants all over the country—to find used or discarded Dart Unions. For *two* reasons. First, old Dart Unions now *belong* back on the job and will work as efficiently as ever. Second, by putting used Darts back to work, you help conserve vital metals.

The explanation of why a Dart Union can be used so many times, with absolute assurance of tightness each time, is found in the way Darts are made. Darts have two extra-wide, non-corroding bronze seats, ground to "true-ball" surfaces. And, the nuts and bodies of all Dart Unions are made of High-Test Air Refined Malleable Iron that resists pipe strains, rough handling, rust.

So we say again: don't delay . . . search your plant for used Dart Unions *today*. If you also need *new* Darts, see your supplier.

DART UNIONS

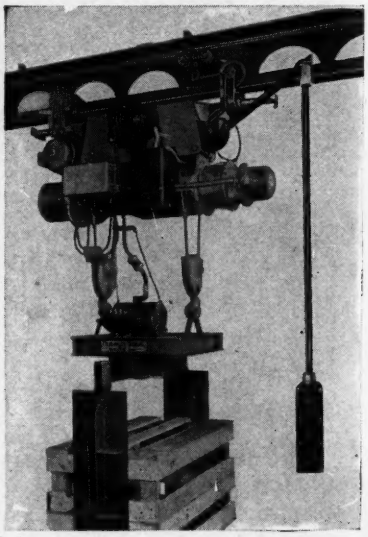
E. M. DART MFG. CO., PROVIDENCE, R. I.

essary to stroke the diaphragm valve.

New design features include Inconel torque tube construction that eliminates stuffing box packing and lubrication, and is supported by a stainless steel knife edge bearing that is free from gumming and sticking. The small rotary shaft turns on a precision-ground ball bearing inside the pilot case. The float lengths from 14 to 120 in. The Level-Trols are available in five types for all service conditions.

Motor-Driven Crate Grab

A MOST RECENT development of the Cleveland Tramrail Division of The Cleveland Crane & Engineering Co., Wickliffe, Ohio, is a motor-driven crate grab and carrier especially designed for handling crates and boxes in and out of storage, or from one elevation to another. The unit enables the quick stacking or removal of crates at a great height with safety. This makes possible faster handling, and also greater storage capacity of a given area.



The grab and carrier are completely motorized with all operations push button controlled. The unit can also be provided with an operator's cab in which all controls may be located.

The arms of the grab are extended and retracted by geared slide bars driven by the motor mounted on top of the grab. Power is supplied through a flexible scale cable held taut by a spring-type retrieving reel.

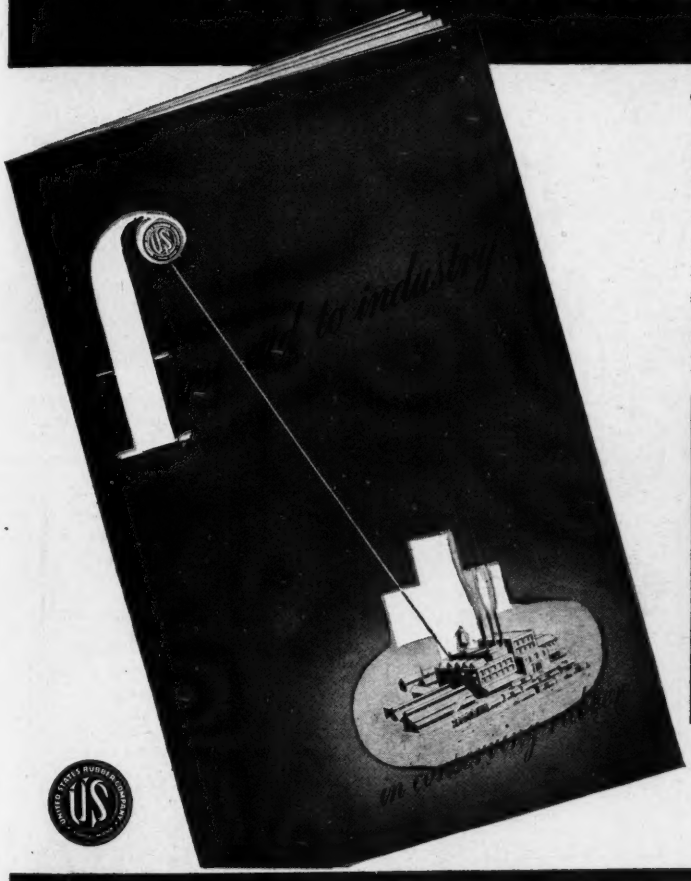
The unit is said to lift loads up to 1500 lb. a distance of 20 ft. The arms spread to a maximum of 36 in. and retracted to a minimum of 18 in. Similar units can be built for heavier loads and to suit other dimensions.

Bomb-Snatcher for Incendiaries

THE BOMB-SNATCHER, a new device manufactured by the McGraw Electric Co., 5201 West 65th St., Chicago, Ill., is intended to snatch incendiaries quickly with safety to the operator.

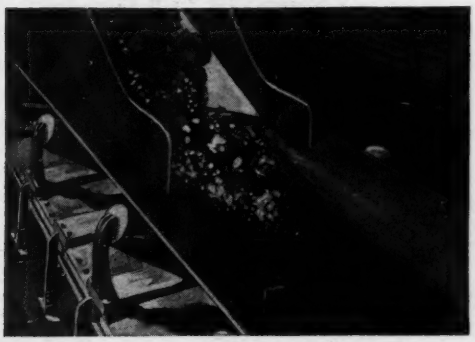
Originally developed for a munition plant making thermite incendiary bombs for the armed forces, it consists of a pair of tongs with semi-cylindrical re-

HOW TO HELP YOUR PLANT IN THIS RUBBER CRISIS



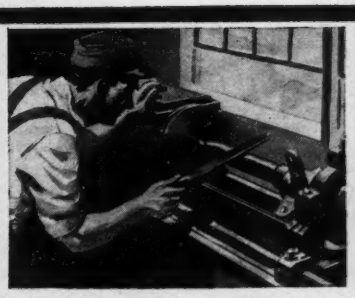
THIS NEW 48-PAGE BOOKLET

is for managers, engineers and plant operating men. It shows how to conserve rubber through proper handling, installation and care by methods such as those illustrated below. Other subjects covered are molded goods, rubber covered rolls, rubber mountings, rubber printing materials, mats and matting, grinding wheels, electrical wires, cables and tapes. Free copies will be sent on request. Write the Mechanical Goods Division, Dept. 20, United States Rubber Company, at address below.



Protect Conveyor Belts by using "V"-shape notch in loading chute to distribute fine material first as cushion for heavy lumps.

Conserve Hose by proper choice and installation of couplings to assure application without injury to hose tube.



Extend Packing Life by examination of equipment, and reconditioning worn moving parts before repacking.

Preserve Rubber Linings from danger due to "changed over" operations, higher temperatures and possible damaging effects of substitute materials.

UNITED STATES RUBBER COMPANY

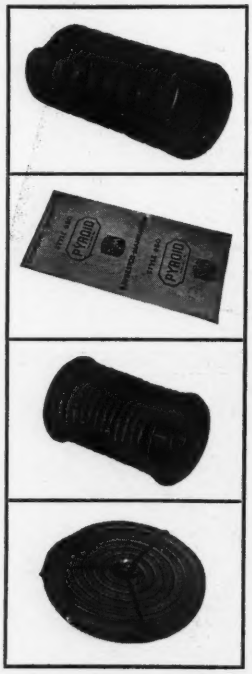
1230 Sixth Avenue · Rockefeller Center · New York

In Canada: Dominion Rubber Co. Ltd. Toronto, Ont.

Figuratively and literally, the heat is on. Production in America is passing all previous records. This means that steam lines, oil lines, fuel lines, and air lines must take higher pressures for longer periods. R/M packings won't let go, won't let you down. They Hold That Line!

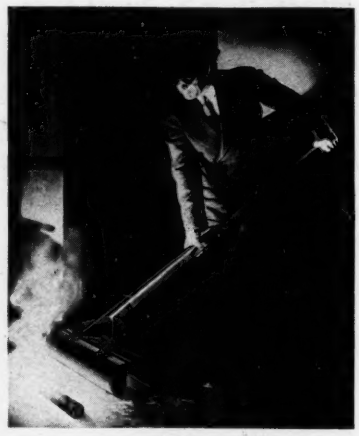
In laboratories and in the field, R/M engineers are testing and re-testing to be sure that these packings can take what all-out production gives. And as a result, R/M packings are giving an even better account of themselves. Rely on R/M!

Do you have a copy of the R/M catalog? It's keyed for applications, illustrated, and indexed as to materials and types. Get a copy of this catalog from your R/M distributor, or write us direct.



INDUSTRIAL SALES DIVISION
RAYBESTOS-MANHATTAN, INC.
MANHEIM, PA.
BRIDGEPORT, CONN. NORTH CHARLESTON, S. C. PASSAIC, N. J.
Makers of Packings for Every Industrial Use

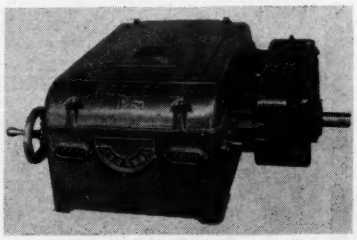
fractory-lined jaws. Pulling back on the lever of the handle causes them to enclose the burning bomb and then drop it into the lower section where it is held as in a trough and the molten, white-hot material prevented from spilling. On magnesium bombs it has a very effective snuffing action. A forward movement of the lever dumps the bomb instantly.



It is said real thermite bombs have been allowed to burn out inside the jaws at a temperature of 4500 deg. without burning through the refractory-lined casing and tests with the explosive discourager type of incendiaries show this causes practically no damage as the upper section is free to open to relieve the pressure of the explosion.

Speed Transmission with Chain Drive Reducer

REEVES PULLEY Co., Columbus, Ind., now offers a special design of variable speed transmission, enclosed design, equipped with built-in chain reducer, and with the output shaft in exact alinement with the input shaft.



Output speeds may be either increased or decreased as compared to the variable speed shaft of the transmission, and of course infinitely variable, within predetermined limits, by turning the speed control handwheel. The chain drive operates in a bath of oil.

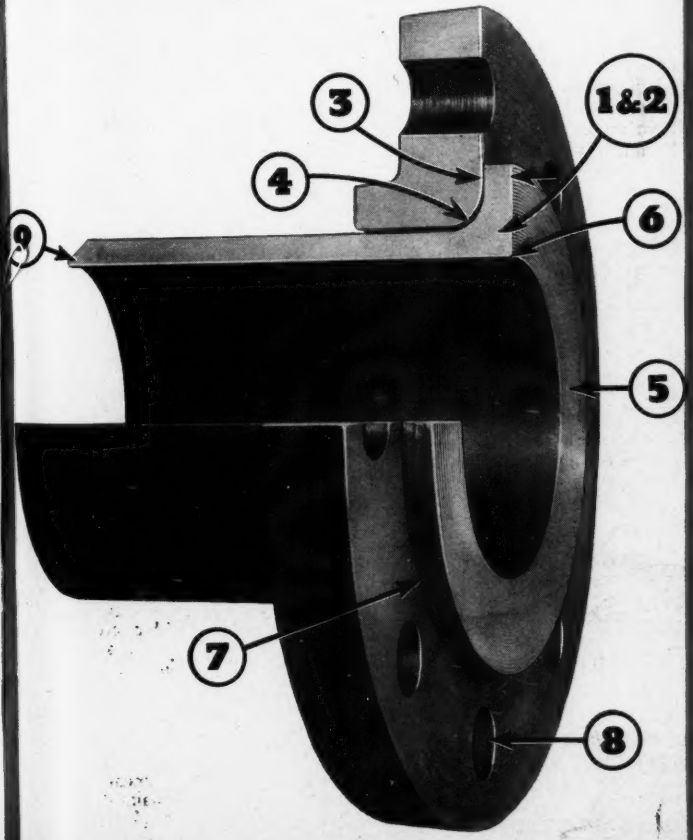
Zeolite Softeners

RESTRICTIONS on new equipment not essential for war production make it increasingly difficult for many plants to obtain new zeolite water softeners. Steps must therefore be taken to increase the capacity and efficiency of water softeners now in use. To this end, Elgin Softener Corp., Elgin, Ill., has developed a new

MIDWEST

LAP-JOINT STUB ENDS

Have MANY ADVANTAGES



1. LAP IS FORGED—by a special Midwest process that simultaneously upsets the pipe and forms the lap. Tests have proved the superiority of this process.

2. STRESS RELIEVED—The metal in the lap is worked at a forging heat and then normalized to assure a uniform, close-grained structure. Photomicrographs show it frequently superior to the original pipe material.

3. HEAVY LAP—Thickness of finished lap (after machining front and back) is always at least equal to pipe wall thickness.

4. LARGE RADIUS FILLET—Assures more metal in the critical area of lap—where maximum total bending and shearing stresses occur. Advantages 3 and 4 are important factors in securing the greatest strength in the lap.

5. PHONOGRAPHIC FINISH—of lap face holds the gasket more securely.

6. SQUARE CORNER (instead of a round corner)—adds to lap strength but also eliminates pockets for accumulation of condensate and sediment that promote corrosion.

7. UNIFORM FLANGE BEARING—Back face of lap is carefully machined to assure the uniform flange bearing necessary to a satisfactory joint.

8. TIME SAVED—in both welding and erection because bolt holes need not be carefully lined up before welding.

9. MACHINE BEVELED—The other end of the Stub End is accurately machined for easy welding.

See Bulletin WF-41 for complete data on Midwest Lap-Joint Stub Ends . . . and the other Midwest Welding Fittings that simplify and save on welded piping.

MIDWEST PIPING & SUPPLY CO., Inc.

Main Office: 1450 So. Second St., St. Louis, Mo.
Plants: St. Louis, Passaic (N. J.) and Los Angeles
Sales Offices: Houston—229 Shell Bldg. • Tulsa—533 Mayo Bldg.
Chicago—949 Marquette Bldg. • Los Angeles—520 Anderson St.
New York (Eastern Division)—30 Church St.
San Francisco—535 Call Bldg.

MIDWEST WELDING FITTINGS SAVE TIME, IMPROVE THE DESIGN, AND REDUCE THE COST OF PIPING SYSTEMS

a new way

TO LIGHT OFF BURNERS THAT'S FASTER-SAFER-MORE POSITIVE

ENCO AUTOMATIC RETRACTABLE OIL-ELECTRIC IGNITION SYSTEM

for lighting off PULVERIZED COAL-OIL-GAS BURNERS WITH REMOTE CONTROL

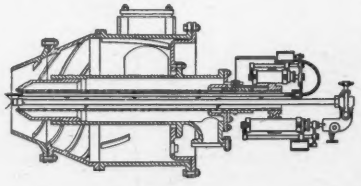
LOSS of ignition for even a short time in a large steam generating unit may, and frequently does have serious results. Turbine operation may be affected, production halted, and process work ruined.

With the Enco Ignition System, the operator can light off any burner by movement of a Hand Control Valve, located close to the pulverized coal mill and fan controls, and within view of the instrument board. Automatically, a powerful ignition spark is established, and the light fuel turned on. Both are interlocked electrically—the oil valve cannot be opened until the spark current is on and the atomizer is in firing position. After the oil flame is established, a second movement of the control valve retracts the electrodes, leaving the atomizer in operation.

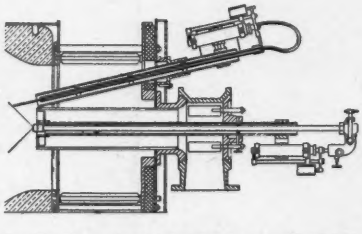
After ignition of the pulverized coal is established, a third movement of the control valve shuts off the oil and retracts the atomizer out of the hot zone leaving the unit ready to repeat the operation as may be needed.

The Enco Ignition System has a wide range of application. Pulverized coal, blast furnace gas or any liquid fuel may be ignited by the unit or the spark alone may be used to ignite natural or refinery gas. The ignition flame can be gradually changed from light to heavy fuel oil if continued operation under heavy load is required. The ignition flame can also be used as a substitute for principal fuel in emergencies.

Send for illustrated booklet describing the equipment, its operation, and how it can be installed in your burners.



Application where atomizer and electrodes are inserted in the central tube.



Application where atomizer and electrodes are inserted in separate tubes.

THE ENGINEER COMPANY
75 West Street • New York, N. Y.

Enco OIL BURNING EQUIPMENT

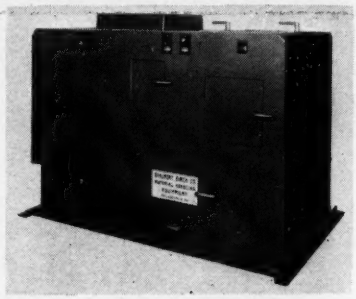
type manifold arrangement which makes it possible to use a far deeper zeolite bed so that the water softening capacity of an ordinary zeolite softener can be stepped up as much as 44 per cent.

By means of ingenious double-check valves, this arrangement, called the Double Check manifold system also prevents zeolite loss, eliminates packing and channeling of the zeolite bed, and makes it possible to backwash and regenerate faster and more efficiently.

This manufacturer also recommends that softener tanks be refilled with new zeolite and points out that replacing standard greensand zeolite with new high capacity greensand zeolite will increase capacity nearly 70 per cent because they say this type mineral is specially processed to give this higher exchange value.

Automatic Scale

AN AUTOMATIC weighing scale designed for rapid and accurate handling of coal and other free-flowing bulk materials is announced by the Beaumont Birch Co., Philadelphia, Pa. An outstanding feature of the new scale is a vibrating metal feeder deck which conveys the material from feed hopper to weighing hopper, thereby eliminating all rubber belts, pulleys and rotating mechanism. The Beaumont-Vibro Automatic weighing scale is totally enclosed in a dust-tight welded steel case. Three standard units are available to handle quantities from 1 to 30 t. per hr. Larger sizes have weighing capacities up to 60 t. per hr.



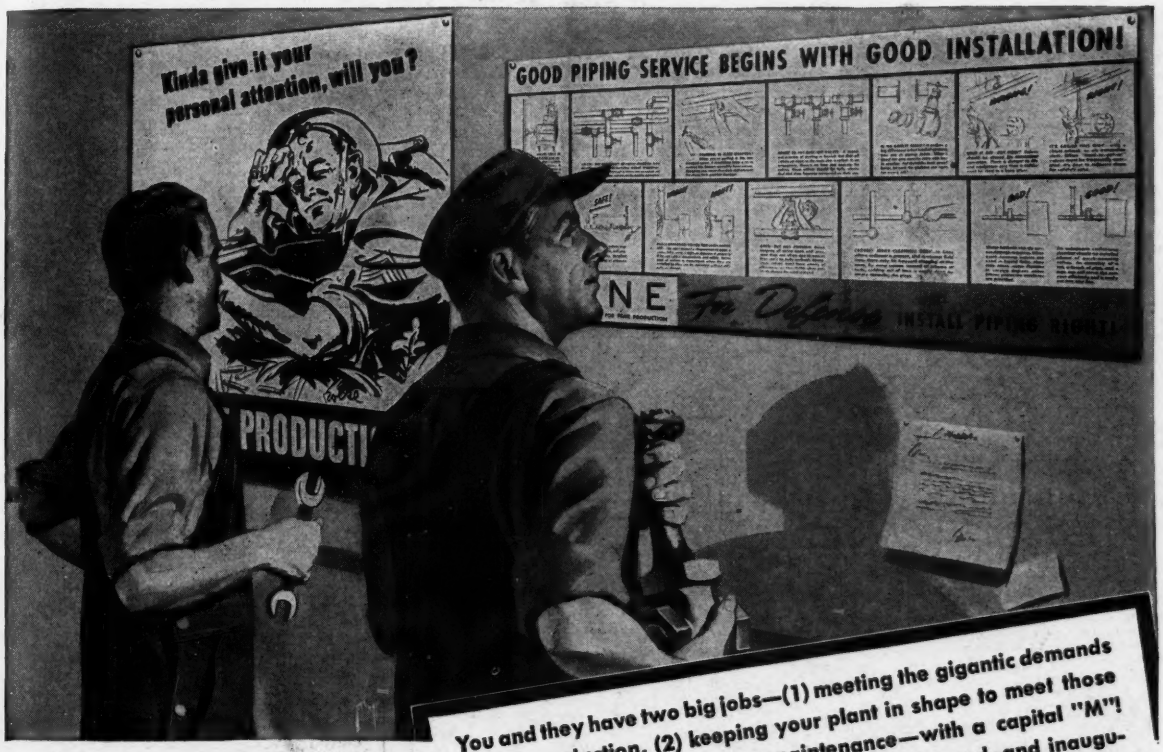
MANUFACTURERS' PERSONALS

Five Receive War Memorial Scholarships

FIVE SONS of employes at the Westinghouse Elec. & Mfg. Co., have been selected as winners of the 1942 Westinghouse War Memorial Scholarships, established in honor of the company's 5000 employes who served in World War 1.

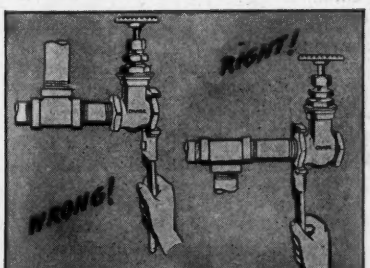
These winners were chosen in the 24th annual scholarship competition from a group of 64 applicants following examinations in 20 cities. Eligibility for the awards requires that the candidates be either sons of Westinghouse employes or young workers themselves.

The educational awards went to Russell R. Boyd of Norman, Okla.; Robert Morie, Wilmerding, Pa.; Clarence W. Whitmore, III, Kenmore, N. Y.; John H. Wright, North Bergen, N. J.; and to Francis E. Wynne, Jr., of Wilkinsburg, Pa. Two of the recipients have completed one year of their engineering training while the other three were graduated from high school this past spring.


Kinda give it your personal attention, will you?
GOOD PIPING SERVICE BEGINS WITH GOOD INSTALLATION!
For Defense
INSTALL PIPING RIGHT!
PRODUCTI

HELP FOR FIGHTERS ON THE *Home Front*

You and they have two big jobs—(1) meeting the gigantic demands of war production, (2) keeping your plant in shape to meet those demands. That means proper maintenance—with a capital "M"! Long before Pearl Harbor, Crane Co. saw this need, and inaugurated "Piping Pointers"—to help you and them do the job. Today, these Crane bulletins on better installation and care of piping are training new workers and spreading the gospel of proper maintenance—for peak production, for conservation of critical materials —for Victory! These examples show how they're doing it.



TREAT PIPING RIGHT is rule No. 1 in making present valves and fittings last longer —give maximum service. In "Piping Pointers," Crane tells maintenance men exactly how to do it—how to avoid little careless habits that shorten the life of equipment—how to prevent replacements now when replacements are harder to get.

PICKING THE RIGHT VALVES for specific services is a sure way to eliminate interruptions and delays in production lines. "Piping Pointers" give clear directions on valve selection. Workers using this service know when, where, and why to install gate valves—when to choose globe, angle or check valves.

FOR TRAINEES OR VETERANS—Men who never handled a wrench before quickly grasp the *do's and don'ts* and *rights and wrongs* in "Piping Pointers." They keep veterans up-to-date on *"kinks"* that speed up work and step up efficiency of piping. For plants using this Crane service, it means fewer shutdowns—*more production!*

FREE—TO ANY PLANT—TO HELP SPEED VICTORY! Your local Crane Representative will gladly supply "Piping Pointers" on request. Or, write to the address given here.

CRANE

CRANE CO., GENERAL OFFICES: 836 SOUTH MICHIGAN AVENUE, CHICAGO

VALVES • FITTINGS • PIPE • PLUMBING • HEATING • PUMPS

NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

James C. Tweedell, export manager of the York Ice Mach. Corp., has been appointed general sales manager for the duration, succeeding John R. Hertzler, who will undertake a special assignment in a civilian capacity with the Army-Navy munitions board in Washington. Mr. Tweedell, a graduate of Rhode Island State College, has been with York since 1924, and has previously been assistant manager of the Industrial division and manager of the Commercial division. He has been manager of the Export division with headquarters in New York City, since 1935.

William H. Sullivan was recently appointed to the marine section of the Westinghouse Elec. & Mfg. Co.'s Washington staff.

He joined Westinghouse in 1936, serving his first year on the graduate student training course in East Pittsburgh. Later he was a sales correspondent for the Steam Division at South Philadelphia, and a steam specialist for the Middle Atlantic and Pacific Coast Districts. He was born at Springfield, Ill. in 1910, and received a bachelor of science degree in electrical engineering at the University of Colorado in 1934.

Frank J. Hill, salesmanager for many years, has recently been elected vice-president of Greene, Tweed & Co., New York City. Mr. Hill has been connected with the company since 1915.

Mark R. Woodward, formerly with Commercial Testing & Engineering Co., Chicago, Ill., is now chief engineer of maintenance, Trojan Powder Co., Plum Brook Ordnance Works, Sandusky, Ohio.

In memory of James Mapes Dodge, pioneer engineer and one of the founders of Link-Belt Co., a ceremony was held at the company's Nicetown, Philadelphia plant on June 30, which commemorated the 90th anniversary of his birth. Mr. Dodge was chairman of the board at the time of his death in 1915.

S. H. Mortensen, engineer-in-charge of alternating current design for 10 yr., has been appointed chief electrical engineer of the Allis-Chalmers Mfg. Co. plants at West Allis, Cincinnati, Boston and Pittsburgh. Starting at the Allis-Chalmers Norwood works in 1905, Mr. Mortensen transferred to Milwaukee as an electrical draftsman 3 yr. later. There he successively became design engineer for direct current machines, design engineer of rotating synchronous machines, and in 1932, engineer-in-charge of alternating current design.

Lynn A. Williams, Jr., secretary of Stewart-Warner Corp., Chicago, Ill., and head of the company's legal department, was recently elected a vice-president of the corporation by the board of directors.

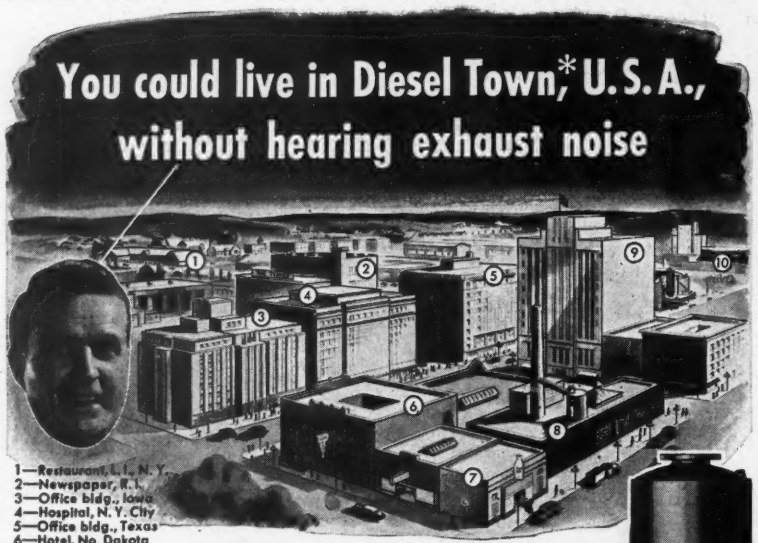
In the 9 yr. that he has been associated with Stewart-Warner, Mr. Williams has been affiliated with most of the important steps that the company has taken as part of a long range expansion program.

As a member of the corporation's new devices committee, which looks into new production methods and products submitted by inventors, he has been instrumental in the development of many of Stewart-Warner Corp. most successful innovations in the fields of radio, refrigeration, lubrication and automotive accessories.

Neil C. Reed was appointed assistant manager of the $14,000,000 Navy propulsion equipment plant which Westinghouse is building in western Pennsylvania. Prior to his new appointment and since 1934 he was manager of the Buffalo office of the Westinghouse Electric Elevator Co. Mr. Reed served overseas with the 75th Coast Artillery in 1918 and 1919. After the war he completed high school, entered Syracuse University and graduated with a degree in electrical engineering in 1926. He joined Westinghouse the same year.

Arthur M. Houser, engineer of standardization, Crane Co., Chicago, Ill., has been appointed consultant in the Simplification Branch of the Bureau of Industrial Conservation of the War Production Board, Washington, D. C.

Mr. Houser has devoted most of his time to standardization work, since the Boiler Code Committee of the A.S.M.E. was formed in 1911. Shortly thereafter the Manufacturers' Standardization Society of the valve and fitting industry was organized with Mr. Houser as one of its founders and an early chairman. He has been active since, and has written many articles on various phases of the subject.


You could live in Diesel Town,* U.S.A., without hearing exhaust noise
1—Restaurant, L. I., N. Y.
2—Newspaper, R. I.
3—Office bldg., Iowa
4—Hospital, N. Y. City
5—Office bldg., Texas
6—Hotel, No. Dakota
7—Dairy store, Mo.
8—Large dairy, Chi.
9—Office bldg., Fla.
10—Water works, Ohio
* Diesel Town—an imaginary city made up of real buildings. Each one has an actual installation of Diesel engines equipped with Burgess Snubbers to provide quiet exhausts.

Snubbers make Diesel Exhausts Quiet

There was a time when Diesel engine operation meant Diesel exhaust noise. That time passed when Diesel operators discovered they could operate their engines efficiently—without exhaust noise—by snubbing the noise-making "slugs" of exhaust gases which would otherwise shoot out of the engine and cause noise.

Now you can live next door to a Diesel plant without knowing it, if its engines are equipped with Burgess Exhaust Snubbers. The buildings shown above are only a few of the many successful Burgess Snubber installations where the advantages of Diesel power are being enjoyed without exhaust noise complaints. Snubbers smooth the pulsating flow of exhaust gases to a quiet stream. There is no interference with the efficient operation of any Diesel engine. Burgess Battery Company, Acoustic Division, 2823-KWest Roscoe Street, Chicago.

Originators of Patented Snubbing Principle for Quieting Diesel Exhausts.

Cross sectional view of Burgess STC Snubber, used for preventing exhaust noise of Diesel engines.

BURGESS DIESEL EXHAUST SNUBBERS

Braze Valve and Pipe Together!

Silbraz Joint

Faircoseal Valves are designed to make a Silbraz joint with Brass or Copper Pipe and Tubing. A Silbraz joint is a silver brazed joint—not threaded—not soldered.

The portway ends of the valve are plain-bored, with a recess in each end. Into each recess there is inserted, at our factory, a ring of Sil-Fos silver brazing alloy. This Sil-Fos ring has exactly the right kind and right quantity of brazing alloy to make a perfect joint without guesswork or waste of material.

After inserting the pipe into the valve port openings, the application of heat from an oxy-acetylene flame causes the brazing alloy to flow evenly between valve and pipe, thus forming a joint that is stronger than the parts joined. In resistance to heat, vibration and torsional strains, Silbraz joints are fully equal to the strength of the pipe or valve.

Faircoseal Valves, for making Silbraz joints, are designed for use with steam, oil, hot or cold water, compressed air, acid, Freon, sulphur dioxide, etc.

Silbraz joints have been approved by the U. S. Navy for use aboard naval vessels and have been incorporated in many U. S. Maritime and U. S. Army specifications.

Write for Bulletin F.S.V., or mail the coupon.

FAIRCOSEAL
BRONZE VALVES

THE FAIRBANKS COMPANY, P.P.E.
399 Lafayette St., New York, N. Y.

Please send your Bulletin FSV.

NAME.....

ADDRESS.....

CITY..... STATE.....

R. M. Kalb Appointed Chief Engineer

THE KELLOGG SWITCHBOARD AND SUPPLY CO., Chicago, Ill., announce the appointment of Robert M. Kalb as chief engineer of the company.

Mr. Kalb, a telephone research engineer of long experience, was previously assistant chief engineer of the company. He is a graduate of Ohio State University, Department of Electrical Engineering and took post graduate work at Columbia University. Later he taught in the Electrical Engineering Laboratory at Ohio State University.

He is known for his research engineering work on transmission and circuit problems, and for 13 yr. was associated with the Bell Telephone Laboratories. A number of patents have been issued to him for improvements on various telephone apparatus.

B. A. Wallace, associated with the Kellogg Laboratory and Engineering Department for many years, has been promoted to the position of assistant chief engineer. He will chiefly be responsible for production engineering.

E. F. Moran Advanced By Westinghouse

EDWARD F. MORAN, graduate of Massachusetts Institute of Technology, and associated with Westinghouse Elec. & Mfg. Co. since 1935, and X-ray sales manager since December, 1941, has been named assistant to the manager of the X-ray division, with headquarters in Baltimore, Md.

Mr. Moran will be succeeded by Chandler S. Eason, manager of the division's Philadelphia office, according to Walter C. Evans, vice-president.

Bonner, Treasurer of Pomona Pump Co.

C. Granniss Bonner

C. GRANNISS BONNER, formerly comptroller and more recently treasurer of The Brunswick-Balke-Collender Co., Chicago, Ill., has been elected treasurer of Pomona Pump Co., Pomona, Calif. Mr. Bonner relieves Donald C. McKenna, vice-president, and former treasurer, who will devote full time to directing production of the company's four manufacturing plants. Mr. Bonner is a graduate of Swarthmore College.

Cutler-Hammer Personnel Changes

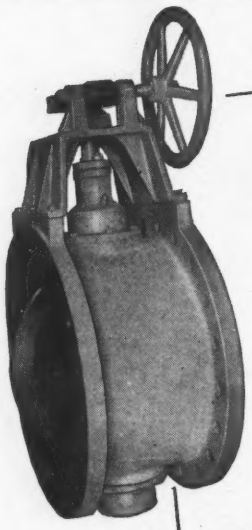
T. N. Bristow

CUTLER - HAMMER, INC., recently announced changes in its selling organization. The New York District office has added J. A. Darnall, a transfer from the Milwaukee, Wis., offices, to its staff at 8 W. 40th St. Philadelphia District office at 401 N. Broad St. receives R. Keeler, transferred from Milwaukee, where he has been in experimental work and sales. The Cincinnati office announces transfer of J. E. McSorley from the resales division in Milwaukee, while the Seattle office becomes a district sales office with T. N. Bristow as district manager.

C. A. Mabey Director of Bristol Co. Research

C. A. Mabey

THE BRISTOL CO., Waterbury, Conn., recently announced the appointment of Charles A. Mabey as director of the research activities of the company. Mr. Mabey, who has served as physicist for several years, is a Harvard graduate and did advanced work in physics at Harvard and M.I.T. He has also been associated in research work with International Communications Laboratories of New York, Federal Telegraph of Newark, N. J., and with Mathieson Alkali Works of New York and is a member of the American Physical Society.



SIMPLIFIED CONTROL and SHUT-OFF for FEED WATER SERVICE

20" 125-lb. American Standard Valve, hand wheel control. Ball bearing mounted with stuffing box. Precision machined and wedge-tight. Manual or automatic control. Six revolutions of hand wheel completely open or close valve.

- Non-complicated construction means minimum maintenance.
- Streamlined vane seats at an angle with wedge-tight precision against body of valve.
- Vane is vibrationless. Self-cleaning and extremely easy to operate.
- Graduated dial and pointer determines exterior position of vane in control of volume and pressure.
- Special R-S pressure iron castings for resistance against heat, abrasion and corrosion. Cost less and more readily procured than steel.
- Sizes to 84-inches and pressures to 300 lb. for many services.

For performance data, specifications and complete details, request Catalog No. 10-B.

R-S PRODUCTS CORPORATION

4535 Germantown Avenue Philadelphia, Pa.

R-S Streamlined BUTTERFLY VALVES

STEAM VALVES
on Chester Station's New No.5 Unit!
by Vogt
Vogt Steel Valves are d-r-o-p f-o-r-g-e-d and that's why they are extra strong and extra tough . . . operating with a maximum of dependability and a minimum of maintenance in exacting flow control services . . . the kind of performance that is a "must" with power plants like Chester Station of the Philadelphia Electric Company.
Chemical distributing system uses 1"-400# globe valves
1¼"-600# gate valves on desuperheater manifold
1½"-1500# globe valves on high pressure drip lines
Vogt FOR BETTER VALVES
HENRY VOGT MACHINE CO.,
INCORPORATED
LOUISVILLE, KENTUCKY
Branch Offices:
New York, Philadelphia, Cleveland, Chicago, Cincinnati, St. Louis, Dallas
½" meter valves on boiler control panel

Save a Helper and Save Time with a ROTO TUBE CLEANER

Right now, when time and skilled labor are at such a premium, is an opportune time to consider the advantages which the New Roto Tube Cleaner can give you. A Roto operating air valve on the motor enables one man to clean tubes faster than when he has to depend upon a helper to turn on and shut off the air between every one of the hundreds of tubes cleaned. The Roto motor delivers more power per cubic foot of air consumed than ever before. Roto cutting heads, universal joints and accessories are built to make and keep customers satisfied. Your plant needs the kind of performance that Roto gives.

SEE OUR ADV. IN SWEET'S

The ROTO Company

145 SUSSEX AVE., NEWARK, N. J.

Roto Model 130 air-driven motor with swing-frame head and air valve for one-man operation in 3¼" curved tubes, and Roto Junior Model 39 air-driven motor with pivot head for 2" tubes.

Change of Address

To avoid missing an issue or paying for forwarding postage be sure to send a change of address to our office. Changes received by the 20th of the month can be made effective for following month's issue.

MANUFACTURERS' NEWS

Following the passing of Morris S. Towson, president of the Elwell-Parker Electric Co., Cleveland, Ohio, the company annouunces the newly elected officers, S. K. Towson, president and general manager and W. A. Meddick, vice-president.

The Worthington Pump & Machinery Co. was recently awarded the Navy "E" pennant at its Harrison, N. J., plant. Also presented were Navy "E" button insignia to the employes of the plant.

Benwood Linze Co. Acquires The Fore Electric

THE BENWOOD LINZE CO., St. Louis, Mo., designers, engineers and manufacturers of electrical rectifiers and rectifier-transformer assemblies recently announced a further step in their overall program of expansion with the purchase of the Fore Electric Co., 4800 Delmar Blvd., St. Louis, Mo. The purchase includes all of the company's equipment, inventory, assets and trade name. All facilities have been moved to the plant of the Benwood Linze Co., at 1815 Locust St.

The Fore Electric Co. was founded in 1917 under the direction of Albert Wehmeier. The company manufactured battery chargers of both vibrator and bulb type, magnetizers, transformers and electrical meters. All products were manufactured under the trade name, "Fore."

The Benwood Linze Co. will continue to manufacture and distribute the products of the Fore Electric Co., including replacement parts for same.

New Navy Plant in 90 Days

IT TOOK just 90 days and a construction technique borrowed from World War I to make ready a new plant for production of Navy material at the Allis-Chalmers Mfg. Co. Practically a self-contained shop, the emergency building is of wood construction with brick facing. It covers an area of 200,000 sq. ft. The wood construction was adopted both to cut construction time to a minimum and to conserve critical materials. Practically the only metal used in the construction are the metal caps at the ends of timber tresses and columns. The metal caps were produced in Allis-Chalmers' own foundry to save time. Electrical control equipment will be manufactured in the new building which will begin to operate as a 100 per cent Navy plant.

Bureau Helps War Plants Get $62,120,464 in June

THE BUREAU OF FINANCE reported July 3 that in June the Bureau obtained $62,120,464 for manufacturers engaged in war production, as compared with $54,476,358 in May.

Below DECKS

THERE are not many valves in the Gun Stations and Fighting Tops of America's Warships. But below decks where the engines stay, there are valves by the hundreds. That they perform their functions dependably and well is as essential as is the performance of many another piece of equipment more easily seen, more often mentioned.

So it is in power plants, refineries, powder plants, chemical industries. Each depends on the precise control of the flow of liquids and gases for proper performance. Each depends on valves for this control.

It is small wonder that in time of war, when every ship must sail, when every factory must produce to the limit, that Powell Valves are in such great demand. For Powell Valves are backed by a century of experience, and a proud record of performance. Powell Engineers are trained to anticipate the demands of Industry. In times of peace this service has been a boon to American Industrial Progress. In times of war it is an essential military requirement.

The winning of a war takes a lot that does not show on the surface. Some of this, particularly valve control, is "below decks."

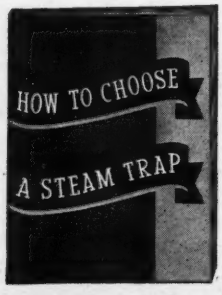
The Wm. Powell Company
Cincinnati, Ohio

Figure 9003 W. E.—Class 900 pound Cast Steel Gate Valve with Welding Ends, Outside Screw Rising Stem, and Bolted Flanged Yoke. Seat and disc are hard faced with Stellite. Available in sizes from 3" to 24". Sizes 6" and larger are regularly furnished with anti-friction bearings in yoke. It is one of a complete line of quality, long-life valves specially designed and built by Powell to provide the Nation's power plants with dependable flow control equipment.

POWELL VALVES

IMPORTANCE of Super-Silvertops in wartime

Anderson's Super-Silvertop Steam Traps are playing their part in helping to win the war. Thousands of these dependable inverted bucket traps are being selected for installation in war production plants because in peace times they definitely proved their dependability in giving uninterrupted, economical service in trapping steam-using equipment. Only Super-Silvertop Steam Traps are distinguished by these three advantages. First, simplified piping; they are used as an elbow or straight-in-line—Second, extra capacity due to a larger guided bucket—Third, passages liberal in area and bored smooth; not narrow cored passages to become clogged with scale and interrupt the flow of condensate. Now is a good time to become acquainted with Super-Silvertop Steam Traps. The way to become acquainted is to send for the book, "How to Choose A Steam Trap" a manual on the selection, installation and operation of steam traps. A letter from you brings a complimentary copy.



THE V. D. ANDERSON COMPANY
1939 WEST 96th STREET • CLEVELAND, OHIO

Super-Silvertop STEAM TRAPS

SAUERMAN POWER SCRAPERS

10 to 600 tons per hour by one man

MAN-HOURS are vital these days. The Sauerman system of moving open storage coal is unique in simplicity of operation and it brings per-ton-moving costs way down. Our catalog describes this economical, trouble-free system. We would like to send you a copy.

SAUERMAN BROS., INC.
586 S. Clinton St.
CHICAGO, ILL.

NEWS FROM THE FIELD

A. S. M. E. & A. I. M. E. Fuels Sessions Announced

THE PROGRAM of the Joint Fuels session of the A.I.M.E. Coal Division and the A.S.M.E. Fuel Division, to be held at the Statler Hotel, St. Louis, Mo., Sept. 30 to Oct. 2, has been announced.

The Hon. Harold L. Ickes, Secretary of the Interior, will be the speaker at the regional meeting banquet held on the evening of the second day of the program.

Papers to be presented at the sessions include: Increasing the Percentage Production of Large Size Coke at Fast Coking Rates to Meet Wartime Demands, by I. M. Roberts, Laclede Gas Light Co., St. Louis, Mo.; Plan to Improve Blast Furnace Coke, by W. T. Brown, Research Engr., Jones & Laughlin Steel Corp., Pittsburgh, Pa.; Density Index Patterns of the Physical Characteristics of Ash and Clinkers from Coal and Admixtures, by R. M. Weimer, Northern Illinois Coal Corp.; Some Ways to Avoid High Stoker Maintenance and Inefficient Combustion, by A. R. Mumford, Combustion Engineering Co., Wilmington, Ill.; The Distribution of Coal Dust by Tank Car as Pulverized Fuel, by Harmon C. Ray, Carter Coal Co.; Combination Coal and Gas Firing, by H. L. Crain, Kansas City Power & Light Co.; Use of Mixtures of Oil and Coal in Boiler Furnaces, by Dr. W. C. Schroeder, U.S.B.M., College Park, Md.; Priorities in Mine Supplies, by D. L. McElroy, University of W. Va.; Meeting Wartime Fuel Problems, by Ollison Craig, Riley Stoker Corp., Worcester, Mass.; and Using Machine Shops for War Production, by A. Lee Barrett, Pittsburgh Coal Co., Pittsburgh, Pa.

Presiding at the Percy Nicholls Award presentation banquet will be A. R. Mumford, Combustion Engineering Co., Inc.

National Chemical Exposition Changed

ANNOUNCEMENT is made by the Chicago Section of the American Chemical Society of a change of dates and location for its second National Chemical Exposition, owing to the acquisition of the Stevens Hotel in Chicago by the United States Army.

The exposition and conference have been transferred to the Sherman Hotel, located at Clark and Randolph Sts., and will take place from Nov. 24 to 29.

Construction on Davis Project to Begin

THE BUREAU OF RECLAMATION, has awarded a contract to the Uth Construction Co., San Francisco, Calif., at $18,996,392 for the construction of the proposed Davis Dam and hydroelectric power plant on Colorado River, and work on project will be placed under way at early date. The award represents a contract on joint bid of company noted and nine other contractors all of same city, including Morrison-Knudsen Co., Macdonald & Kahn, J. H. Pomeroy & Co., J. F. Shea Co., Raymond Concrete Pipe Co., Pacific Bridge Co., Winston Brothers, Griffith Co., and Stanley Bent, which will cooperate in the different features of construction. The dam site is about 30 mi. west of Kingman, Ariz.,

WeldELLS

It's the difference between RIGHT and WRONG —*this "selective" reinforcement*

BOTH mathematical calculations and practical tests* prove that the bursting stresses in an elbow are greatest at the crotch or inner wall. That's why a special process is employed in producing WeldELLS which provides extra metal in this region of greatest stress as pointed out above. It is the nearest possible approach to the "One Hoss Shay" ideal of absolutely uniform strength throughout.

And it's also one more example of the length to which we have gone in producing WeldELLS to follow sound engineering considerations—considerations which mark the difference between right and nearly right.

An extra value, this—and opposite are listed other extra-value features that are combined in no other fittings for pipe welding. Yet: WeldELLS cost no more!

WeldELLS have *everything*—

No other fittings for pipe welding combine the features found in WeldELL. In addition to that described, they include:

▶ **Seamless**—greater strength and uniformity.

▶ **Tangents**—keep weld away from zone of highest stress—simplify lining up.

▶ **Precision quarter-marked end**—simplify layout and help insure accuracy.

▶ **Permanent and complete identification marking**—saves time and eliminates errors in shop and field.

▶ **Wall thickness never less than specification minimum**—assures full strength and long life.

▶ **Machine tool beveled ends**—provides best welding surface and accurate bevel and land.

▶ **The most complete line of Welding Fittings and Forged Steel Flanges in the world**—insures complete service and undivided responsibility.

* The amount by which stress is greater at the crotch in a fitting having uniform wall thickness depends only on its radius. Mathematical analysis (specifically the Lorenz formula) shows the stress at the crotch to be:

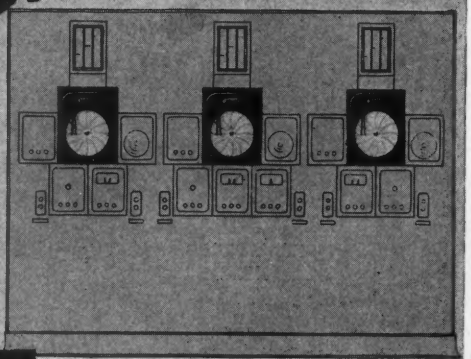
$$S = \frac{pr\,(2R - r)}{2t\,(R - r)}$$

Where S = Bursting stress, lbs. per sq. in.
p = Internal pressure, lbs. per sq. in.
r = ½ inside diameter of fitting (O.D. if Barlow's formula is desired).
t = Wall thickness in inches.
R = Center line radius of fitting, inches.

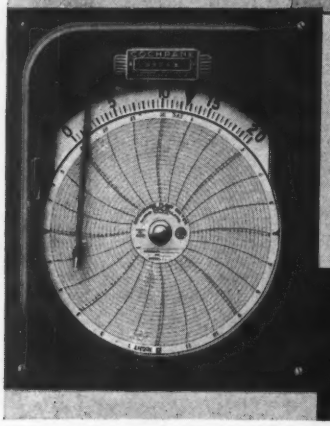
Numerous tests by the Research Division of Taylor Forge show the formula given above to be somewhat on the conservative side.

TAYLOR FORGE & PIPE WORKS, General Offices & Works: Chicago, P. O. Box 485
New York Office: 50 Church Street • Philadelphia Office: Broad Street Station Bldg.

THE FLOW OF TANKS in this great Tank Arsenal is being recorded in the pages of History



The boiler instrument and control panel board shown at the right is installed in one of our great tank arsenals. Three Cochrane Electric Flow Meters measure steam flow and flue gas temperature. Hays draft gages and controls complete the panel.



THE humble part played by Cochrane Flow Meters in the thousands of power plants that are back of the greatest production drive in history is important because the information furnished by these meters is unfailingly accurate. Cochrane records can be depended on. The reason lies in Cochrane basic design and Cochrane construction. Cochrane design employs the NULL Balance principle, balancing the unknown quantity by adjusting a known quantity of the same kind, a highly sensitive detector being used to determine the point of balance. Friction is eliminated in the transmitter and a powerful external motor drive relieves the measuring circuit of all work. Write for 56-page Publication 3010.

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FLOW METERS

More for Your Money

Because advertising is so widely used in the United States, we are the best informed people in the world on what there is to buy, what it will do for us and where to buy it. Because advertising is one of the most economical parts of the selling process and helps identify power plant products of known performance value, it is an important aid in getting more for your money.

and approximately 67 mi. below Boulder Dam on the same river. The structure will be of earth and rock fill type; it will be 138 ft. high above river bed, with crest length of 1600 ft., which will be provided with a roadway 44 ft. wide. The project primarily is for the development of power, but will provide, as well for river regulation. The power station will be 110 by 448 ft., situated at the downstream toe of the concrete penstock structure. It will be equipped with five 45,000-kv-a. electric generating units, for which award has been made to General Electric Co., at price of $2,487,000. The project will require about 6,000,000 cu. yd. of excavation, 445,000 cu. yd. of concrete, 14,000,000 lb. of concrete reinforcing bars, and approximately 11,300,000 lb. of gates, penstocks and miscellaneous structures.

Houston Lighting & Power Co., Houston, Tex., has begun work on proposed new steam-electric generating station on tract of about 100 a. of land on Houston-Richmond Highway, near the city limits. This plant, to be known as the West Junction generating station, will have an initial capacity of 35,000 kw. Reported to cost close to $2,000,000, including switching station, transmission lines and other structures. It is planned to have the station ready for service around the close of the year. Ebasco Services, Inc., 2 Rector Street, New York, N. Y., is consulting engineer.

Consumers Power Co., Jackson, Mich., has arranged for the purchase of tract of approximately 200 a. of land on Muskegon Lake, Muskegon, Mich., as a site for a future power plant. The tract formerly was held by the Muskegon Booming Co., Muskegon, and used as a log-sorting grounds. It has a frontage on the lake of about 1 mi. and was secured for a reported consideration of about $60,000.

Buffalo Niagara Electric Corp., Buffalo, N. Y., has completed construction of an addition to its Charles R. Huntley generating plant on River Road. Work will begin soon on installation of the turbine-generator unit, being built by General Electric. The boiler unit will have a capacity of 900,000 lb. of steam per hr. at 1500 lb. pressure and will be fired by pulverized coal. The plant is scheduled for operation early next fall and will include additional transmission lines and enlargement of switchyard at the plant.

Government Takes Over Yadkin Project

THE HYDROELECTRIC project on the Yadkin River, near Clemmons, N. C., initially begun by the City of High Point, will be taken over by Government, through the PWA, and used as source of Federal power. Work suspended a number of months ago will be resumed soon. The project, as originally designed by Murray & Flood, Inc., 369 Lexington Ave., New York, N. Y., consulting engineer, covered the construction of a power dam about 85 ft. high, with 21,000-kw. initial capacity, divided into three 7000-kw. hydraulic turbine units.

The Government will arrange for various changes in design, with adjustment of former contracts for work made by the city and the awarding of additional contracts as required. Ad-

There go your Valves!

Honor to you men who wait so that America and her ships can have valves some of you need so desperately.

* * *

"TO AMERICAN SHIPS! MAY GREAT FLEETS OF THEM SAIL FORTH—TO RETURN, SOON, WITH PEACE."

We can drink that toast together for we sweat with you. Scarcely had READING-PRATT & CADY completed tremendous additions to capacity—to meet the greater demands you were making for READING-PRATT & CADY VALVES—than came Pearl Harbor. Immediately following, we heard the call for more ships than the world had dreamed possible to build. Every ship is a maze of valves. And we were asked to take the responsibility for many of them.

Round-the-clock production was put in force at once. But your deliveries have been and are delayed—longer than we hoped for—and the problem is complicated by certain shortages. We believe that many of you see that this is the only road to travel today—that when you hear of fleets of American ships carrying their precious cargos to far corners of the world, you get no small measure of satisfaction from realizing that valves you might have had, helped do the job.

READING-PRATT & CADY

MANUFACTURERS OF R AND P&C CO. VALVES AND FITTINGS

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A DIVISION OF ACCO AMERICAN CHAIN & CABLE COMPANY, INC., BRIDGEPORT, CONNECTICUT

Don't Let the Matter of Priority Stop You from Planning for the Future . . . . . .

● This is the MURRAY type "UG" Integral Geared Turbine with low speed gear shaft extended for belt drive. This turbine rated 100 h. p., 2400/400 r. p. m., operates at 160 lbs. initial pressure, D. & S. and 40 lbs. back pressure. This particular unit is in use driving a paper machine in a paper plant in Michigan.

MURRAY TURBINES
WITH HIGH OVERALL EFFICIENCY
have proved exceptionally dependable in all production eras for 15 YEARS . . . .

★ There are many types of MURRAY Turbines. The "UG" shown here is used to drive low speed machinery. There will be many of these machines to drive in the future as well as high speed machinery—power ever will be the basis of production.

With expanded production facilities, we are doing our utmost to make deliveries in accordance with priorities. You may not be one to get a MURRAY Turbine on priority, but you certainly will when victory comes to America. So, plan now for your turbine needs—let's talk it over—in the meantime why not send for MURRAY Bulletins so that you will have the details before you.

BOILERS TURBINES ENGINES

MURRAY IRON WORKS COMPANY
INCORPORATED 1870
BURLINGTON IOWA

BETTER SERVICE — SAFETY — SATISFACTION
FOR REPLACEMENTS ORDER

PRECISION GAGE GLASSES and GAGE GLASS GASKETS THAT WILL NOT BLOW OUT

Standard Square Cut Gaskets High Pressure Non-hardening and Non-softening

GASKETS THAT WILL FIT EXACTLY

Red Lip-mold Pattern Expansion Type Gasket

Send for Glass and Gasket Chart

Shipment made by parcel post the same day as order is received

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RUBBER & GLASS DIVISION LIVINGSTON, NEW JERSEY

ditional land will be acquired for the project and William F. Freeman, High Point, consulting engineer has been engaged to make surveys for this phase of the project. W. R. Holway & Associates, Tulsa, Okla., consulting engineers, have been commissioned to redesign the project for Federal needs. Part of the output of the new plant will be used by Carolina Aluminum Co., at its works at Badin, N. C. It is said, also, that power will be secured from the new source by Carolina Power & Light Co., Raleigh, N. C., for transmission and distribution, to serve Federal munition plants in its territory.

Help Put Empty Cylinders To Work

PRODUCTION requirements today are such that there is an increased demand for oxygen and acetylene. This demand can be met if empty cylinders are returned promptly and if cylinder stocks in the hands of users of oxy-acetylene welding and cutting are maintained at a minimum.

Cylinders must be kept moving. They must not be permitted to stand idle, either full or empty. The cylinder supply, now the most important factor in the distribution of compressed oxygen and dissolved acetylene, is still deemed adequate to keep these gases continually and readily available to essential users if all will co-operate in speeding up turnover rates.

Also, refrain from ordering more oxygen or acetylene than is required for immediate needs. Many shops allot not more than three oxygen and three acetylene cylinders to every two welding or cutting outfits in active service. This plan permits a 50 per cent reserve.

This appeal is made just as much to small shops, using two or three cylinders a month, as it is to large plants using up to one hundred or more cylinders a month. For every day a cylinder is empty and idle is a day lost out of its productive life regardless of the size of the shop.

OBITUARIES

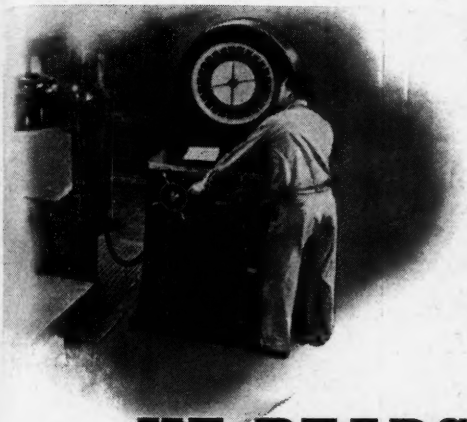
Charles L. Meyer

CHARLES L. MEYER, mechanical and sales engineer with the L. J. Wing Mfg. Co., New York, for the past 18 yr., died June 26, at his home in Hollis, L. I.

Mr. Meyer, born in New York City on August 25, 1889, attended Manual Training High School and Pratt Institute and spent 3 yr. at the Brooklyn Polytechnic College. He was with the Brooklyn Edison Co., as engineering assistant from 1908 to 1910. With Westinghouse, Church, Kerr and Co., he worked on power plant layouts, and in heating and ventilating. He was Fire Apparatus Test Engineer for the New York Central and Hudson River Railroad Co., and later with the Westinghouse Machine Co., New York, as chief draftsman and engineer.

From 1915 to 1921 he was with the National Aniline and Chemical Co. The following year he was sales engineer for United Lead Co. and in 1924 he became sales engineer in charge of sales for L. J. Wing Mfg. Co.

Mr. Meyer is survived by his widow, mother, two brothers and two sisters.



HE READS THE *"Life-lines"* OF GLOBE PRESSURE TUBES

The life expectancy of a Globe Pressure Tube is an open book to the Globe metallurgist. Frequent laboratory tests, including photomicrographic inspection, in addition to careful and thorough individual gauging for wall thickness and outside diameter, insure a consistently uniform quality of product.

Such extra precautions in manufacture may readily be translated into longer life and greater safety in use. This extra margin of safety and strength means lower cost in the long run for the user of Globe Pressure Tubes.

Globe Engineers are always available to assist in selecting a tube with the exact characteristic you require.

GLOBE STEEL TUBES CO., Milwaukee, Wis.

STAINLESS TUBES
BOILER TUBES
CONDENSER AND HEAT EXCHANGER TUBES
MECHANICAL TUBING

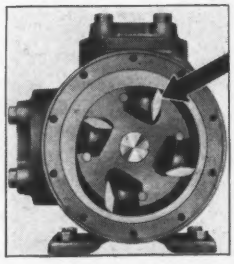
GLOBE STEEL *Tubes*

GLOBE TUBES

168-HOUR ★ PUMPS ★ WEEK IN . WEEK OUT

AND NO DROP IN CAPACITY—

that's why you find BLACKMER ROTARIES DOING THE "TOUGH PUMPING JOBS" IN WAR PRODUCTION PLANTS



the BUCKETS

(swinging vanes) make Blackmer Pumps self-adjusting for wear, insuring constant volume. When the buckets are finally worn out, a 20 minute replacement job restores the pump to its original efficiency. A set of "buckets" costs but a few dollars.

THESE MATERIALS and many others are handled efficiently by BLACKMER PUMPS:

Acids
Alcohols
Asphaltum
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Brines
Caustics
Coal tar
Crude oil
Dyes
Foods
Gasoline
Naphtha
Lube oil
Paints
Soaps
Solvents
Syrups
Yeast

TAKE CARE OF YOUR PRESENT PUMPS

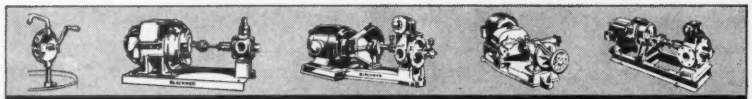
Blackmer engineers have prepared this material to help you maintain your present pumps at greatest efficiency.

Bulletin 301: "FACTS about ROTARY PUMPS," complete operating data on swinging-vane type pumps.
Bulletin 302: PUMP ENGINEERING DATA, useful tables on pumps and piping.
SER-1: "TEN WAYS TO MAKE ROTARY PUMPS LAST LONGER," a maintenance check-list in handy card form.

THESE BULLETINS ARE FREE TO PLANT MEN. Write Blackmer Pump Company, 2018 Century Avenue, S.W., Grand Rapids, Michigan, for your copy today.

POWER PUMPS
5 to 700 GPM
HAND PUMPS
54 models.

AVAILABLE NOW ON PROPER PRIORITY RATING. We can ship standard units promptly upon rated orders. Write us your requirements.



BLACKMER Rotary PUMPS

"BUCKET DESIGN"—SELF-ADJUSTING FOR WEAR

WHEN YOU WRITE TO ADVERTISERS

When writing advertisers for catalogs, descriptive bulletins or prices, please remember to say, "I saw your message in POWER PLANT ENGINEERING." Thus you'll do a good turn for the advertiser and for this publication. . . . . .

NEW ENGINEERING BOOKS

The Entire Electromagnetic Spectrum. Compiled by the Westinghouse Research Laboratory. Copyright 1942. Printed on cloth in seven colors. Size 40 by 30 in. Published by the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Price $2.00 (while the limited supply lasts).

This excellent chart, printed in seven colors on cloth, with a transparent plastic front which can be cleaned with a damp cloth, is mounted on rollers so that no frame is required. It covers the entire spectrum from a frequency of 10 up to 3×10^{25} c.p.s. (wave lengths in meters from 3×10^{7} to 3×10^{-17}). In Angstrom Units, this is from 3×10^{17} to 3×10^{-7}, ranging from power and light on one end through induction heating, radio waves, infra-red, ultra-violet, X-rays, Gamma-rays and secondary cosmic rays on the other.

In addition to the primary spectrum, there are six secondary strips showing various sections of the spectrum to an expanded scale. These six are: the induction heating spectrum from 60 to 6×10^{6} c.p.s.; the radio spectrum from 1 to 30,000 meters; the infra-red spectrum from 8000 to 2×10^{6} Angstrom Units; the ultra-violet spectrum from 120 to 4100 Angstrom Units; the X-ray spectrum from 0.8 to 5 Angstrom Units; and the photographic spectrum from 1500 to 11,000 Angstrom Units.

This last spectrum shows the wave lengths of the elements from mercury on one end to helium on the other, with the central section colored to show the visible light range from blue through red. All of the charts have marked on them the practical use of the different wave lengths. The radio spectrum has in addition a clear designation of the wave length allotted to experimental government and commercial use in this and other countries. A glossary of special terms in one corner of the chart adds greatly to its usefulness.

Heating, Ventilating, Air Conditioning Guide, 1942 Edition. 1256 p., 6 by 9 in., cloth bound, illustrated. American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York, N. Y. Price $5.00. With thumb index, $5.50.

This informative volume is issued annually. In 1922 the first issue of the Guide was a book of only 350 pp., limited in its coverage of the technical phases of the industry and in the presentation of manufacturers' equipment data. Contrasting with this, the 1942 edition contains 1256 pp. and treats exhaustively every phase of heating, ventilating and air conditioning, and related phases of refrigeration.

In this edition it has been the objective of the Guide Publication Committee to present the latest available authoritative information on the vari-

Craftsmanship

NAVCO

POWER PLANT PIPING

• **The bending of pipe is an operation which requires considerable more skill than is evidenced by mere observation.**

Of great importance is the manner in which the pipe is prepared to insure the finished bend having a smooth, clean inner surface free of embedded impurities, wrinkles or buckles.

For hot bending, Navco shops are equipped to mechanically ram a special grade of sand compactly in the pipe, thus insuring a minimum amount of thinning in the outside wall.

Before shipment, every Navco pipe bend is internally turbined with tube cleaner to remove all traces of sand or scale. Where such scale and sand is not removed, it will frequently loosen up in service and destroy turbine blading and valve seats, clog traps and in short, impair the operation of any mechanical equipment to which the piping system is connected.

Every pipe bend and every piece of piping material turned out by Navco shops is of a distinctly superior type of craftsmanship. It has been fabricated by master craftsmen.

NATIONAL VALVE & MFG. CO., PITTSBURGH, PA.

[ATLANTA BUFFALO CLEVELAND CHICAGO NEW YORK PHILADELPHIA]

TEST TUBES SAVE WATER TUBES

Haering products and Haering service are directly stepping up war production. They control corrosion in boilers, condensers and engine cooling systems and all water equipment used in gasoline production, munitions, tanks and many other war products.

Our ability to read water and our many glucosate correctives are doing active service in war industries.

Send for booklets on scale and corrosion control, cooling waters, proportioning problems.

Write for sample containers and data forms to give us a complete picture of your problems.

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"WE READ WATER"
GENERAL OFFICES: 205 West Wacker Drive
CHICAGO, ILLINOIS

Ways In Which Wartime Advertising Helps You

SOMEONE said recently that "advertising is a convenient and effective channel for getting useful information from where it is to where it is needed".

Using POWER PLANT ENGINEERING as such a channel, scores of advertisers are now passing along practical wartime information on how and where to apply power equipment to increase plant capacity, to facilitate conversion to war production, to guard against shutdowns, to reduce maintenance expense.

Now more than ever before it will pay you to read the advertisements in POWER PLANT ENGINEERING. They can help you keep posted on new and better operating methods, aid you and your plant to contribute more fully to the nation's all-out "battle of production".

ous subjects covered in the 47 chapters. In accordance with the policy established by its founders, approximately one-half of the Guide chapters have been revised. Of these, nine were completely rewritten. In this edition, a new chapter has been added on the fundamentals of Heat Transfer, which includes the basic equations for conduction, convection and radiation. Some revisions have been made in the chapters on Thermodynamics of Air and Water Mixtures. The Mollier Diagram for Moist Air has been redrawn and a new Volume Diagram for Moist Air has been added. The data on Physiological Principles have been revised to include current knowledge on thermal interchanges taking place between the human body and the environment. The chapter on Central Systems for Comfort Air Conditioning has been completely rewritten.

In addition to many other changes, the chapter on Radiant Heating has undergone major revisions and contains essential data for the design of radiant heating systems. A new duct chart has been added to the chapter on Pipe and Duct Heat Losses.

The final chapter is on Terminology and constitutes a complete glossary of terms used in the text and in addition lists standard abbreviations, conversion equations, drafting symbols and a specific heat table.

Security for Industrial Plants. Prepared by the Navy Department. For sale by the Superintendent of Documents, Government Printing Office, Washington, D. C. Size 6 by 9 in., paper bound, 25 pp. Price 10 ct.

This pamphlet has been prepared as a guide to the management of industrial plants to assist in building and maintaining a security program to insure continuous production of essential material. Plants working on War and Navy Department contracts have been advised on specific security measures. This pamphlet is intended primarily for those plants which have not had the benefit of specific advice concerning their properties.

The booklet is divided into several sections, one dealing with general information regarding security, one with the development of internal security plans, and one with passive defense. There are also several appendices covering contracts, as well as legislative and executive orders dealing with espionage, sabotage, aliens and specific definitions of what constitutes vital military and naval installations.

Water Handbook, 64 pp. Size 8½ by 11 in., spiral bound. Published by W. H. and L. D. Betz, Gillingham and Worth Sts., Frankford, Philadelphia. Pa. Price 50 ct.

In this concise yet comprehensive handbook prepared by the chemical engineers associated with W. H. and L. D. Betz, the power and industrial engineer will find not only complete instructions for making water analyses for various impurities but also interpretations of analyses of waters intended for use in different industries.

Now Building....

36,000 SQUARE FEET LUMMUS SURFACE CONDENSER For A Well-Known Central Station

Two large surface condensers under construction at Honesdale plant. Right: conventional, external type atmospheric relief valve. Left: Lummus built-in type of atmospheric relief valve — saves space, provides additional support.

Among several large surface condensers under construction at the Honesdale plant of The Lummus Company is a 36,000 square feet condenser. Interesting features of Lummus design contributing to the efficiency of this condenser are:

Distinctive tube sheet layout, providing large internal steam space, permitting free longitudinal steam distribution.

Full deaeration within the condenser—all condensation being run over plates and exposed to live steam.

Entire design, including air coolers, contained within circular shell — no external steam domes or other parts to take up unnecessary space.

Write for data on Lummus Surface Condensers, Steam Jet Air Pumps, Extraction Heaters and other heat exchange equipment.

THE LUMMUS COMPANY · 420 LEXINGTON AVE., NEW YORK, N.Y.

LUMMUS

NICHOLSON TRAPS

Need But a Few Degrees Differential Between Steam and Condensate To Open Valve, Prevent Steam Waste

Other Nicholson Products—

Piston and weight operated steam traps, compressed air traps, gasoline traps, steel and stainless steel floats, flexible couplings, 3 and 4-way valves, compression shaft couplings, expanding mandrels, arbor presses, steam eliminators and separators. Descriptive Bulletins on Request.

OTHER features which help Nicholson Industrial Steam Traps insure better drainage of unit heaters, pipe coils, water heaters, etc., include:

NO AIR-BINDING—All types discharge air just as efficiently as water.

NO FREEZE-UPS—Types A, AU and C drain completely when cold, hence cannot freeze.

NO ADJUSTMENT—Same adjustment used for any pressure from vacuum up to the maximum allowable with construction used.

NO DRIBBLING—Closes immediately when steam contacts bellows.

Write for Steam Trap Catalog No. 941.

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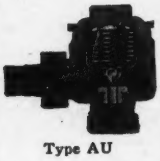

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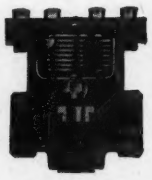

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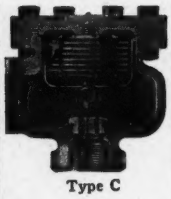

Type C

W. H. NICHOLSON & CO.
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NEW BULLETIN SHOWS WHAT BEARING METAL TO USE WHERE!

SEND FOR YOUR FREE COPY . . . fact-packed NEW data book shows how to substitute lead-base babbitts for tin-base bearing metals . . . tells which metals to use under all service conditions.

MAGNOLIA METAL CO.
18 West Jersey Street, Elizabeth, N. J.

MAGNOLIA BEARING METALS

In the first section, 25 different methods of water analyses are discussed at length, with procedures and calculations. Such water analyses as hardness, alkalinity, phosphate, sulfite, turbidity, oil, calcium, specific conductance, etc., are covered. With but one exception, all tests are simple accurate determinations requiring little or no previous chemical background. Bacteriological analyses are not included.

The second section of the book is devoted to interpretations of the tests and their application to plant control. Included here are discussions of such subjects as Carbonate and Non-carbonate Hardness, pH Control, Steam Purity, Inter-crystalline Cracking, Corrosion, and many others.

Scattered throughout the Water Handbook are sixteen useful technical graphs and fifteen illustrations of different pieces of testing equipment.

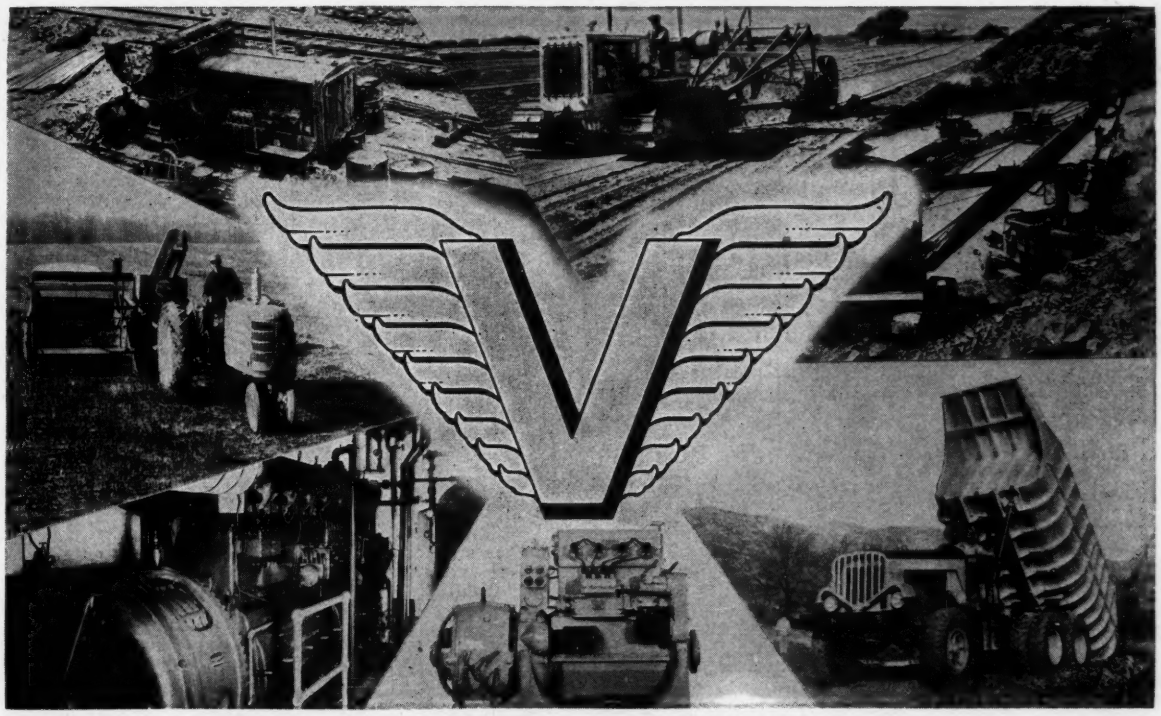
Plastics. By J. H. DuBois. Copyright 1942. Size 5½ by 8½ in., 280 pp., cloth bound. Published by the American Technical Society, Drexel Ave., at 58th St., Chicago, Ill. Price $3.00.

At this particular time when plastics are beginning to take such an important place in industry, this book is very timely. The author has played an important part in the field of plastics since its infancy and for many years has been in the Plastics Department of General Electric Co. and thus is in a strategic position to treat the subject from the matter of basic design information required by engineers and designers and to present the essential information on plastic material properties in a usable form.

It explains in an interesting form the various materials required and how they are put together to form plastics. It gives an excellent historical account of discoveries and developments in this field but does omit formal chemistry to stress how all plastic materials are used, what can be done with each and treats in considerable detail the industrial application of molding, laminating, compression and transfer molding, injection molding and continuous extrusion.

Lessons in Practical Arc Welding. By W. J. Chaffee. Copyright 1942, 188 pp., paper bound. Size 5½ by 8 in. Published by Hobart Trade School, Inc., Troy, Ohio. Price 75 ct. Special prices to schools.

This book explains the fundamentals of arc welding in a simple and easily comprehensive manner and contains the complete series of 41 arc welding lessons offered at the Hobart Trade School. Chapter headings include Preliminary Instructions; Starting and Manipulating the Arc; Welding Common Joints with Bare Electrodes; Welding Light Gage Sheets with Coated Electrodes; General Welding with Coated Electrodes in the Flat—Horizontal—Vertical—Overhead Position; Pipe Welding; Welding Cast Iron; Special Practice and Tests. Text also contains a suggested classroom procedure and ready reference index together with questions listed within each chapter.



Speed Victory

. . . with efficient, non-stop Diesel operation!

TODAY, every Diesel engine owner has his marching orders — *full speed ahead for maximum-production!* That means fewer stoppages, less frequent overhauls. Parts must last longer —even though your engines are driving harder than ever.

There must be no slack, no let-up, no time-out for repairs. For wartime production is a race against Time — and every hour counts!

Your big problem, then, is how to get steady, non-stop operation for longer periods between overhauls.

That's one problem a Cities Service lubrication engineer knows how to handle. Out of long experience, he has the indispensable "know-how" and the exclusive Cities Service instruments with which to tackle your particular job. And he'll be glad to help.

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Proceedings, Thirty-fifth Annual Convention, Smoke Prevention Assn. of America. Size 8½ by 11 in., 137 pp., paper bound, mimeographed text and illustrations. Published by Smoke Prevention Association of America, Inc., 139 N. Clark St., Chicago, Ill. Price $1.00.

This volume contains full copies of all papers presented and stenographic reports of discussions and Association business proceedings that took place at the annual meeting held in Cleveland, O., June 2 to 5, 1942. Among the principle papers included are: Coal—Its Relation to the War, by Thomas J. Thomas; Reports on Dust Fall Survey in Cleveland, O., Over Four Years Period, by Arthur E. Hutchison; A Study of Atmospheric Pollution, by W. F. Davidson; Ohio Coals, by H. M. Faust; Chimney Performance and Its Relation to the Smoke Problem, by J. G. Mingle; Smokeless Heaters—Dream or Reality, by Ralph G. Sherman; Fuel Conservation in Domestic Usage, by James C. Parks; Abatement of Nuisances Caused by Discharge of Metallic Oxides from Non-Ferrous Secondary Metal Smelting Plants, by E. G. Dolezal; Railroad Practices in Abating Smoke from Locomotives and Eliminating Air Pollution, by J. P. Driscoll; Smoke Abatement in War Time, by Sumner B. Ely; Diesel Locomotives, by Chas. H. Longman; Influence on Atmospheric Pollution of the Exhausts from Diesel Automotive Vehicles and Locomotives, by R. J. Bender; Fuel Economy on Railroad Locomotives, by Theodore Olsen; and How Smoke Regulation Departments Can Assist in the War Project of the Control, Allotment and Conservation of the Nation's Coal, by J. F. Barkley.

Metallurgy. By Carl G. Johnson. Copyright 1942, enlarged and revised edition, 262 pp., 127 illustrations. Size 5¾ by 8½ in., cloth bound. Published by The American Technical Society, Drexel Ave., at 58th St., Chicago, Ill. Price $2.50.

Intention of this book is to present information on the subject of metals in such a way that the average individual who has had no opportunity to study the subject will be able to obtain some working knowledge of the manufacture and behavior of metals and their alloys. The science of physical metallurgy is stressed more rather than chemical metallurgy due primarily to the practical value obtained by the student of engineering.

The revisions were undertaken in view of the growing importance of metallurgy in industry, and the consequent importance of some practical knowledge of metallurgy on the part of the many men who come in contact with the metals.

Ideal for regular vocational, trade and technical schools, the text is comprised of information on: properties of metals and tests to determine their uses chemical metallurgy; producing iron and steel; physical metallurgy; shaping and forming metals; commercially important nonferrous alloys; copper and its alloys; heat treatments for steel; surface treatments; alloy on special steels; classification of steels; powder metallurgy, and literature of metallurgy.

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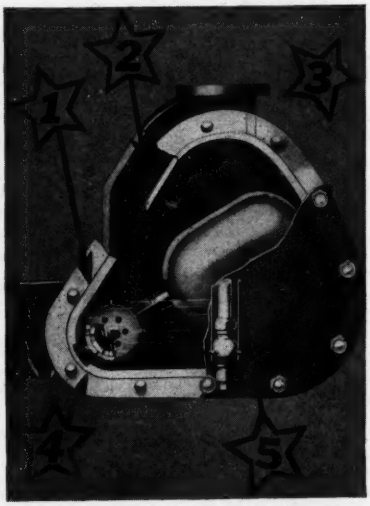

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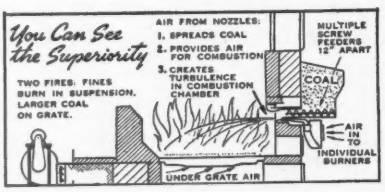
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Milling Machine. By the Staff of the Dunwoody Industrial Institute. Copyright 1942. Size 10⅞ by 8½ in., 110 pp., paper spiral bound. Published by the American Technical Society, Drexel Ave., at 58th St., Chicago, Ill. Price $1.25.

The book, in manual form, covers jobs in connection with the setting up and operation of the various types of milling machines. These jobs give practice in the various operations and processes performed on different machines; in the selection and use for different purposes of milling tools and devices; and in the use of measuring tools and calculations. Listing 35 jobs, the manual includes a list of materials and tools needed, general instructions and a step by step procedure of working operation. Complete details of each job are thoroughly illustrated, and each has a list of precautions, references, and a questionnaire check sheet.

This book is one of a series of six manuals on job training units for training on various machine tools. The others, headed under Machine Shop Training are The Instructor's Guide, Bench Work, Drill Press, Grinder, Lathe, and Shaper and Planer, and were reviewed on p. 136 of the June, 1942, issue.

Bibliography on Circuit-Interrupting Devices, 1928-1940. Copyright 1942, 28 pp. Size 8½ by 11 in., paper bound pamphlet. Published by the American Institute of Electrical Engineers, 33 W. 39th St., New York, N. Y. Price 80 ct. (To AIEE members 40 ct.)

As a second bibliography of technical literature, this publication is comprised of a compilation of practically all material on the subject published in American technical and trade press and the principal articles published in other countries for the period 1928 to 1940. The contents include subjects on circuit breakers (air, oil, water, rapid reclosing, recovery voltages, general and miscellaneous); enclosed switchgear: air switches; bus bars and fuses and fuse protection. Reference items are divided into the subject sections, consecutively numbered, subdivided by years and listed alphabetically for each year.

Physics for Engineers. By Sir Ambrose Fleming. Copyright 1942, size 5¾ by 8¾ in., 232 pp., 89 illustrations, cloth bound. Published by The Chemical Publishing Co., 234 King St., Brooklyn, N. Y. Price $3.00.

This book, written with special reference to the requirements of engineers is a practical survey of present day knowledge in the realm of Physics. Also, written in simple, concise form, it summarizes those parts of Physics which are most necessary for the practical engineer.

The subject of Physics in this book is chiefly sub-divided into: fundamental units; matter and electricity; forms of energy; energy transformations; electrostatics and electromagnetism; electric current and measurement; radiation and the quantrum theory; thermionic and photoelectric emission; electron optics and wave theory of matter; sound, music and telephony; alternating electric currents and supersonic vibrations; and atomic transformations or atom-smashing. The book should be of special interest to every engineer.

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Sound Measurement Test Code for Centrifugal and Axial Fans. Copyright 1942, First edition, 8 pp. Size 8½ by 11 in. and known as Bulletin, No. 104. Published by the National Association of Fan Manufacturers, 5-208 General Motors Bldg., Detroit, Mich. Price 10 ct.

The bulletin was prepared by the Engineering Committee of the N.A.F.M. in order to provide a standard method for measuring sound in fans and blowers. Incorporated in the Code are standards previously adopted by several bodies and commonly used methods of sound determination to give designers and users a relative idea of sound determination. The standardization program was undertaken in response to public demand for lower sound levels in the operation of machinery.

Price Control. Copyright 1942, 149 pp. Size 8½ by 10½ in., paper bound. Compiled and published by the Research Institute of America, Inc., 292 Madison Ave., New York, N. Y., as Research Analysis 21. Price $2.00.

The importance of price control and its relationship to American business during wartime is vastly important. While production is needfully centered on producing war materials, buying power fills the pockets of those who work on these materials. This combination of acute scarcity and heavy buying power, without effective price control, threatens inflation. And runaway inflation can do more damage to our war effort than a thousand bombs dropped on our munitions production centers.

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Also included are texts of the law and general regulations, and digests of price schedules and regulations.

Two other analyses dealing with the present war emergency were reviewed in the April, 1942, issue of Power Plant Engineering: Priorities and Allocations, as Research Analysis 18, reviewed on p. 148, and priced at $1.00; and Producing for War, as Research Analysis 20, reviewed on p. 150, and priced at $2.00.

The Effect of Range of Stress on the Fatigue Strength of Metals. By James O. Smith, has recently been published by the University of Illinois, Urbana, Illinois. A glossary of recently published treatise of the Engineering Experiment Station is included. Price 55 cts.

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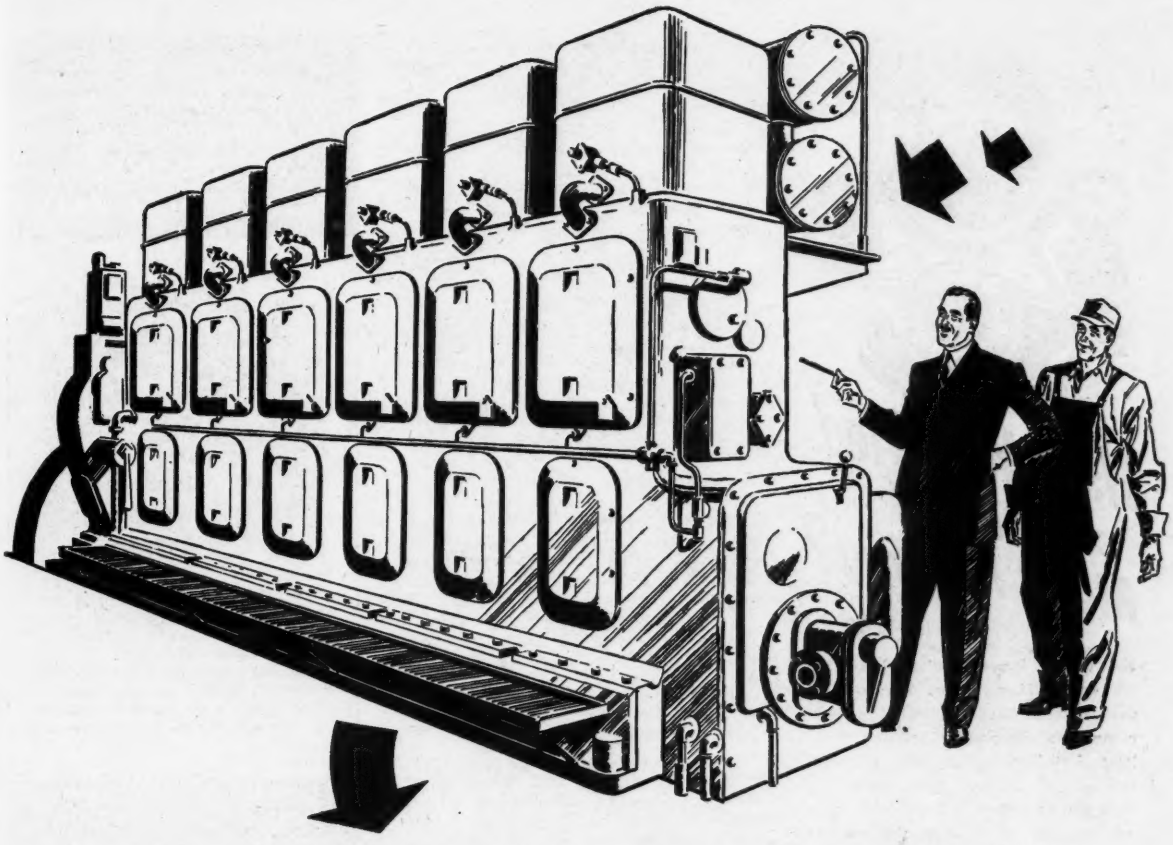

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Plane Trigonometry Made Plain. By Albert B. Carson. Copyright 1942, size 5¾ by 8½ inches, 389 pp., 198 illustrations, cloth bound. Published by The American Technical Society, Drexel Avenue at 58th Street, Chicago, Illinois. Price $2.75.

A practical "how to do it" book, dealing with the fundamentals of trigonometry in great detail and with special attention devoted to numerical work and also emphasizing the application of trigonometric principles in the solution of everyday problems.

The text is presented in a very comprehensive manner so as to enable the student to visualize how and why the principles are employed and their purpose. Typical problems illustrate the practical uses of trigonometry in its own field as well as a stepping stone to higher mathematics. Introduction of logarithms in the early part of the book bring out any possible deficiencies, giving any required remedial study, as well as to facilitate calculations and prepare the student for more advanced principles where logarithmic treatment is necessary.

Tables of logarithms of numbers, natural trigonometric functions and logarithms of trigonometrical functions are contained in the book, and also numerous questions with answers, practical problems and summary are included at the end of each chapter.

Introduction to Heat Transfer. By Aubrey I. Brown and Salvatore M. Marco. Copyright 1942, first edition, size 6 by 9 in., 224 pp., cloth bound. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York City. Price $2.50.

Heat transfer as a specialized branch of engineering cannot be underemphasized from the standpoint of practical design and application. There are several good texts available but these assume that the reader has advanced training in sciences, particularly mathematics. The treatment in general engineering books is usually too brief to provide an engineer or student with a workable knowledge of the subject.

The authors of this book felt that there was need of a text lying between the two extremes, one that was easily comprehensible and at the same time covered the ground thoroughly without advanced mathematics other than simple algebra, simple dimensional analysis or elementary calculus.

Emphasis is placed upon acquiring a clear conception of the manner in which heat is transmitted and upon the development of fundamental mathematical expressions which apply to the calculation of heat transfer through clean surfaces.

An attempt has been made to include data from authoritative sources with a caution, however, that the correlation of results of different experimenters is often poor and calculated results are subject to error from this source. They feel that engineers engaging in heat transfer work must, and do, soon learn for themselves the difficulties encountered in an attempt to find close agreement between calculated and experimentally determined results.

The authors are, respectively, Professor of Heating and Ventilating and Assistant Professor of Mechanical Engineering at Ohio State.

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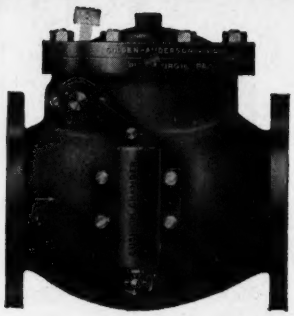

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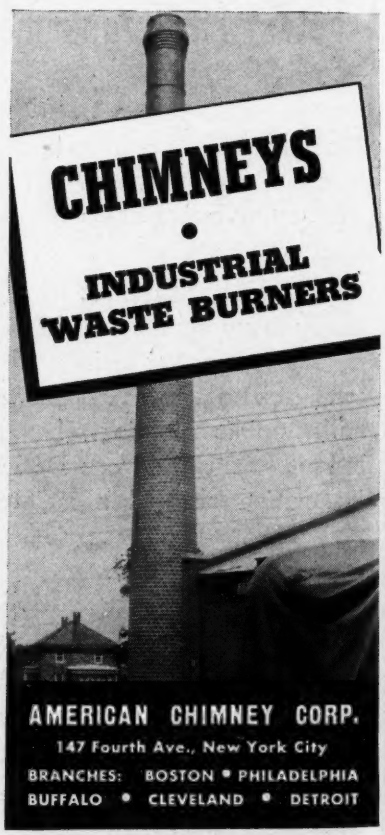

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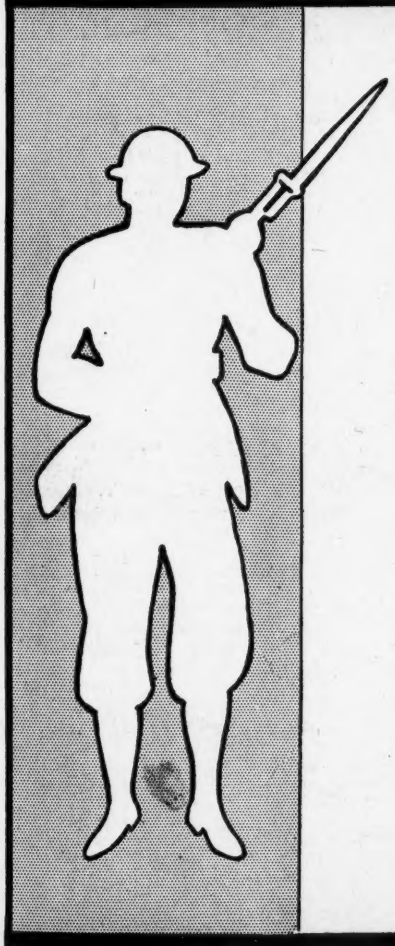

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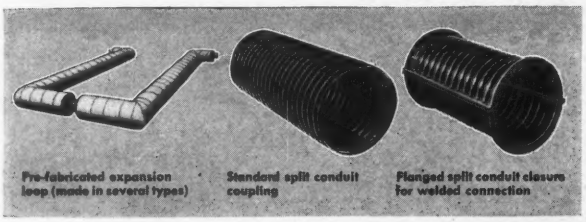

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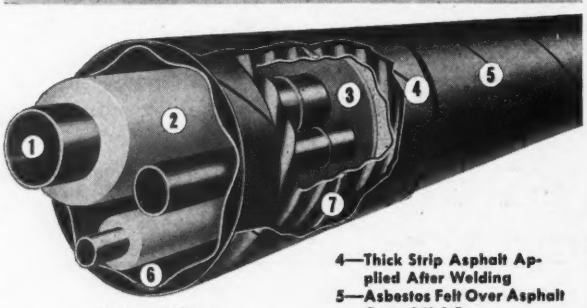

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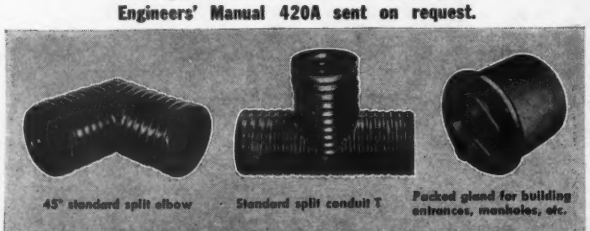

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The Chickamauga Project. Technical Report No. 6, published by the Tennessee Valley Authority, Treasurer's Office, Knoxville, Tennessee. Size, 6 by 9 inches, 451 p., 97 illustrations, cloth bound. Price $1.00.

The book describes the Chickamauga Project and how it fits into the program for unified development of the Tennessee River system. It covers preliminary investigations for the project, including geology, river flow, and social and economic studies; lock, dam, and powerhouse design; access routes to the dam site; construction methods, including construction plant and river diversion; relocation and adjustments made necessary by creation of the reservoir; initial operations; and a complete summary of the project costs. The appendixes include a complete statistical summary of the physical features of the project; reports of engineering and geologic consultants; summaries of special tests such as model studies; the rules and regulations of the employes' retirement system; the agreement between Tennessee Valley Trades and Labor Council and the TVA; and the TVA Acts. Bibliographies on each phase of the project are also included.

The first three reports, No. 1 on The Norris Project, published in 1939 at $1.50; No. 2, on The Wheeler Project, 1940, at $1.00; and No. 3, on The Pickwick Landing Project, 1941, at $1.00, reviewed on p. 138 of the July, 1941, issue of POWER PLANT ENGINEERING, may be procured from the Superintendent of Documents, Washington, D. C. Report No. 4, The Guntersville Project, 1941, at $1.00, review on p. 144 of the September, 1941, issue, may be procured from the TVA Treasurer's Office, Knoxville, Tennessee. Report No. 5, on The Hiwassee Projects, is being postponed pending completion of recently authorized additional projects in the Hiwassee River Basin.

These series of projects along the Tennessee River, when completed, will form one of the finest hydro developments in the country.

Elements of Heat Transfer and Insulation. By Max Jakob and George A. Hawkins. Copyright 1942, size 6 by 9¼ in., 169 p., cloth bound. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $2.50.

Restricted to the few basic principles of heat transfer and insulation, and to their application to simpler problems, this textbook presents a course in heat transmission not designed for the graduate level, but adapted to the average junior or senior engineering student. This text may serve as an additional brief book in the usual thermodynamics course if no special course in heat transmission is offered, thus giving the student a more complete picture of the scientific fundamentals of heat engineering. The various subjects treated in this book are presented in a broad manner with examples following the derivations.

Conduction, convection, and radiation are treated separately first, and then in their combinations. One chapter is devoted to the basic property of thermal conductivity with particular attention to practical insulations. Graphical representations make unsteady state equations palatable to the student, while dimensional analysis is dealt with in the most elementary manner. Applications of heat transfer in experimental engineering and the interdependence of heat transfer and surface friction are treated in the last three chapters. In order to facilitate the solution of the problems, the contents pages are supplemented by a list of tables and figures needed for numerical calculations, followed by a list of symbols. Also included is a selection of literature references at the end of each chapter.

An Oil Burner Handbook. By L. J. Whelan. Copyright 1942, 2nd Edition, size 5½ by 7½ in., 245 p., cloth bound. Published by The Master Plumber & Heating Contractor, 554 Atlantic Ave., Brooklyn, N. Y. Price $2.50.

Written in concise everyday language, this book on knowing how to repair and service your own oil burner is intended for average oil burner dealers, home owners and installation or service men. Segregated into three parts, Domestic Oil Burners, Industrial Oil Burners and Care of the Oil Burner, its chapters discuss fuel oil, combustion preheaters, boilers, oil burners, storage tanks and piping, installation, electricity, controls, servicing and use of tools. Information on how to start the burner, regular care, definitions, rules and regulations pertaining to installation and use of oil burning equipment and a list of pertinent questions at the end of each chapter are also included.

Of special note is the fact that since conservation of valuable fuel oil is in effect, this treatise may find much important usage by the average oil burner mechanic.

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for our armed forces . . .
for our wartime industries

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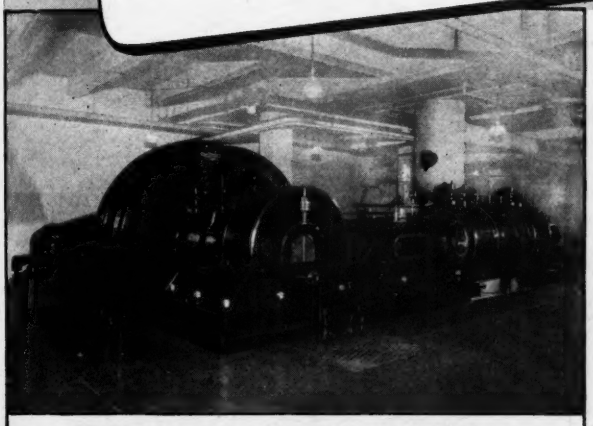
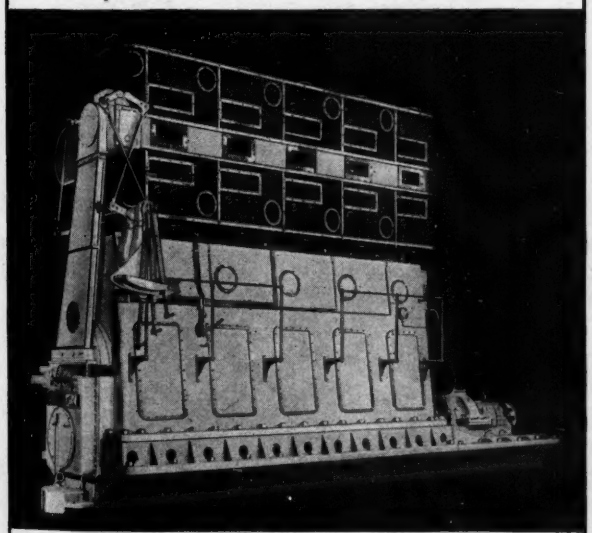


Typical horizontal "Universal Unaflow" engine-generator installation. Multi-cylinder vertical "Universal Unaflow" engines also in general use.



5-cylinder 4,500-shaft horsepower Skinner Marine Unaflow Steam Engine—the largest in the world.

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SKINNER Engines have seen active service with our armed forces before. In World War I, when the A. E. F. needed steam engines, we built them. ***We have a bigger job to do in this war.***

For the duration, the building of Skinner Marine Unaflow Steam Engines is of vital importance. Marine engines are not new to us — in recent years a large part of our plant capacity has been devoted to their production. In peacetime these engines are used for tugboats, ferryboats, lighters, towboats, dredges and other craft of similar size, where economy, simplicity, low maintenance, durability and maneuverability are prime considerations. Now they are being produced as speedily as possible for war service.

Of equal importance is the manufacture of stationary Skinner "Universal Unaflow" Steam Engines, horizontal and multi-cylinder vertical, for the economical and dependable production of electric power, and for driving compressors, pumps and blowers. Large numbers of these engines are now being built, but their availability is of course limited at present to Government service institutions and industries supplying war materials.

Nor are we forgetting the thousands of industrial plants where Skinner steam engines are already generating power required for the increasing flow of war essentials. Service to these plants will be available at all times.

Building steam engines exclusively has always been our job, but right now we must deliver more of them to help win this war.

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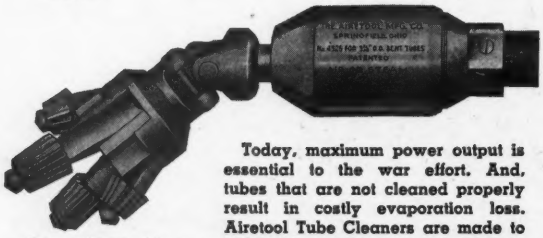

Today, maximum power output is essential to the war effort. And, tubes that are not cleaned properly result in costly evaporation loss. Airetool Tube Cleaners are made to clean tubes inside or outside with a minimum of down time. An ingenious power seal in Airetool Motors is the key to valuable extra power. Self Feeding Cutter head combinations for the toughest scale deposits can be used. Motor can be loaded down to 50 RPM without stalling. And, it will pick up instantly when air is applied. Sizes for straight or bent tubes ½" to 20" I.D. Air, steam or water driven motors.

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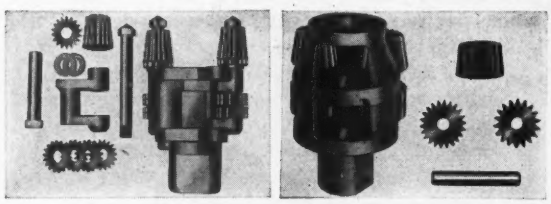
Combining two factors . . . the best alloy steels and rugged construction . . . makes for low maintenance costs. All wearing parts of Airetool Tube Cleaners are made of carefully selected, alloy steels that are properly heat treated. Those things, plus complete inspection, mean a lot to the user. When parts do wear, they can easily be replaced from our complete stock. The slip-fit construction of Airetool Motors makes possible quick, easy replacement of parts without special tools.



CUTTER HEADS

Cutter heads especially designed for every scale condition are made by Airetool. Two are shown above to illustrate the replaceable parts. In addition to the many cutter heads, there are Brush Heads, Drill Heads and Knocker or Vibrator Heads. (The latter are used for removing scale from the outside of tubes.) Airetool New Form Cutters will not track or damage valuable tubes.

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Airetool Tube Cleaners are also made to remove light or heavy scale in straight or bent small tubes such as are found in superheaters, condensers, air coolers, air preheaters and all other tubular construction. They clean thoroughly without damaging the tubes. Heads are available for all scale or gummy conditions.

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FOR THE ENGINEER'S LIBRARY

Coupon for obtaining free literature listed here may be found on page 158, under the heading Helpful Bulletins.

Steam Plant Equipment

1 **Gas and Oil Burners**—Type MU combined heavy duty gas and oil burners for refinery furnaces are described in 4-p. Bulletin No. 702. Complete with illustrations, the bulletin also includes data on installation and air register and information on firing with gas or oil. Peabody Engineering Corp.

2 **Steam-Jet Ejectors**—Bulletin W-205-B7A describes condensing and non-condensing types of steam-jet ejectors and gives engineering data for estimating purposes. Standard materials of construction and schematic drawings are also included. Worthington Pump & Machinery Corp.

3 **Fans**—Catalog 460 describes the new Victory Axiflo seven-bladed fan with a direct connected turbine or integrally mounted motor drive. Available in a wide range of sizes for 1750 r.p.m., operation at pressures ranging from ½ to 60 in. B. F. Sturtevant Co.

4 **Rotary Blowers**—Information on positive displacement type blowers is given in 20-p. Bulletin 22-23-B-11. Illustrated and described are design and construction features for blowers in a wide range of industrial applications. Relief valves and accessories, specifications and a table of standard gear sizes 8 to 22 in. diam. are also included. Roots-Connersville Blower Corp.

Instruments and Controls

5 **Electronic Instruments**—A 16-p. bulletin describes and illustrates unit construction of temperature controllers and explains the electronic principle for effecting control without contact between the measuring and control functions of the instrument. Remote controllers, combustion safeguard equipment and other instruments are also detailed. Wheelco Instruments Co.

6 **Gas Pressure Control**—A 12-p. data folder No. 39 describes the application of telemetering to the measurement of gas distribution pressures. Also contained is information concerning remote pressure measurement and remote automatic pressure control and also information concerning a number of typical illustrated installations. The Bristol Co.

7 **Mechanical Feeder Control**—An illustrated bulletin entitled Automatic Control for Mechanical Feeders on Pulverizing Machines deals with electronic control which automatically regulates feeding rate in accordance with various materials and varying conditions. Also included are typical installations. Mosher Automatic Controls.

8 **Gas Analyzers**—4-p. Bulletin 20-D describes the new Ellison portable gas analyzer. This combustion testing set is completely detailed and illustrated and its construction includes various improvements over previous analyzers. Ellison Draft Gage Co.

Water Treatment

9 **Condensate Corrosion Control**—Case history data on condensate corrosion control by the Haering Process of direct introduction of chemicals into the steam has been released in a 6-p. pamphlet which tells the story of a severe condensate corrosion condition in the Cook County Nurses Home where double extra heavy wrought iron piping failed in 30 da. service. D. W. Haering & Co., Inc.

10 **Zeolite Softener**—Elgin Double Check Zeolite Water softener equipment is illustrated and described in a new 4-p. folder entitled Bulletin No. 605. The design is said to increase softening efficiency and increase capacity, making it possible to use more Zeolite in a given softener without loss. Elgin Softener Corp.

THE ALDRICH-GROFF "POWR-SAVR" CONTROLLABLE CAPACITY PUMP

Two of the three Aldrich-Groff "Powr-Savr" Pumps in the Provo Utah Municipal Power Plant. Each has a capacity of 60 G.P.M. against 450 lbs. pressure.

The performance records of the main boiler feed pumps at the Provo Utah Municipal Power Plant would bring joy to the heart of the thriftiest Scot. These three Aldrich-Groff "Powr-Savr" Pumps have been *"the major contributing factor to the low station power consumption which runs consistently below 4.5% of the gross generation".*

Aldrich-Groff Pumps provide for automatic or remote manual control of delivery, from zero to full capacity, at constant pump speed. Rate of delivery is controlled by varying the length of the plunger stroke, and power consumption is almost directly proportional to pump delivery. These units combine the positive displacement and high efficiency of the plunger type pump with the flexibility and smoothness of the centrifugal pump. Their use is advantageous for main boiler feed in small and medium sized boiler power plants and de-superheating feed service in even the largest power installations.

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Engineers realize that the heat loss from makeshift steam lines can be very costly for the duration.

This is why more and more ADSCO-Bannon Tile Conduit is being ordered for the steam and hot water lines at army camps — naval and air bases, defense plants and housing projects. Available with base drain, in sizes from 4"- 24" inclusive, with ADSCO Filler Insulation — a "Fiberglas" product, it makes a PERMANENT installation of high thermal efficiency.

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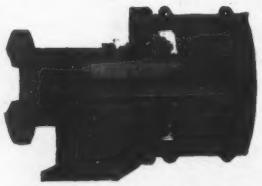

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Save yourself unnecessary correspondence and phone calls — avoid the hazards of divided responsibility — maintain a better working schedule by ordering all your steam line equipment from ADSCO—Conduit—Insulation — Expansion Joints — Pipe Line Accessories, etc.—everything you need for efficient and economical steam line installations.

AMERICAN DISTRICT STEAM COMPANY NORTH TONAWANDA, N. Y.
Making "UP-TO-DATE" Steam Line Equipment for over 60 years

11 **Water Treatment**—Corrective Chemical Feeding is the title of a new 12-p. Bulletin 101-B, which contains helpful technical data on problems of corrective chemical feeding for water refining and gives a guide as to the proper type of equipment selection. American Water Softener Co.

Motors and Electrical Equipment

12 **Motor Control**—Neo-Time-Current is a new method of acceleration described in Booklet-1041. The accelerating unit is used to automatically control the closing of the acceleration contactors which short out the resistances in the secondary circuit of the a.c. wound rotor motor. The action is accomplished by a simple electronic circuit. The Electronic Controller & Mfg. Co.

13 **Motors Maintenance**—A Guide to Wartime Care of Electric Motors is a new approach to the maintenance problem of motors under hard service and unfavorable conditions. It is applicable to all types of motors and tells the cause and correction of troubles due to dirt, oil, moisture, vibration, misalinement, wear and overload. A check list of symptoms you can see, hear and feel serves as a diagnosis chart. Sent to executives, engineers and maintenance men requesting a copy on company letterheads. Allis-Chalmers Mfg. Co.

14 **Electrical Equipment**—An attractive 42-p. Booklet GEA-3395 containing almost 200 photographs of applications and products illustrates and describes the wide range of precision-built equipment G. E. offers for the aircraft industry. Included are load-center power distribution systems, motors and controls for many uses, resistance welding controls, arc welding equipment, heat-treating equipment, testing equipment, lighting, etc., and such equipments for the plane as instruments, voltage regulators, motors, amplidyne sets, relays, generators, dynamotors, superchargers, radio and others. General Electric Co.

Miscellaneous

15 **Air Conditioners**—A new 24-p. Bulletin G-2 describes the principles of operation and construction of capillary cell air conditioners. These cells utilize many thousands of fine glass filaments to effect a direct heat transfer surface between water and air. The bulletin presents useful information on evaporative cooling, and, by means of blue prints shows the application of these capillary air conditioners to a variety of purposes. Air & Refrigeration Corp.

16 **Conveyor Belting**—For those in charge of conveyor and elevator belting, a new 24-p. illustrated catalog, Section 2800 on the care and maintenance. Contains a variety of useful information on the care and maintenance of belting. It also lists a wide range of belt data. The B. F. Goodrich Co.

17 **Conveyor Pulleys**—Bulletin CP-42 should be of special interest for those using conveying equipment of the solid and split type conveyor pulleys. Tabulated information is incorporated on sizes, approximate weights and applications. The American Pulley Co.

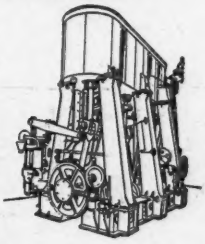
18 **Maintenance Materials**—A new operating practice manual gives many practical suggestions on getting better service from maintenance materials. Entitled 101 Suggestions for Good Operating Practice, the guide, Form PP-9A, outlines in tabular form many hints on lengthening the life of packings, insulations, roofings, friction materials, and refractory products. Johns-Manville.

19 **Flexible Coupling**—The story of what a flexible coupling should do and the function of the coupling is described in Bulletin 642 which also illustrates some heavy duty installations. Installation information is given together with standard key dimensions and a repair parts price list. W. H. Nicholson & Co.

20 **Air Raid Protection**—Blackout, air raid damage and glass splinter protection for industrial plants through the use of the Ozite air raid safety and blackout blankets is described in a 12-p. comprehensive analysis. Clinton Carpet Co.

Modernized Steam Engines

for LIBERTY SHIPS



Liberty-type cargo ships were wanted in a hurry but turbine building plants were choked with work for combat ships. So the Maritime Commission specified triple expansion reciprocating engines and these are now being produced in many plants throughout the country by companies such as Worthington Pump & Machinery Corp., General Machinery Corp., Willamette Iron & Steel, and many others.

A modern feature added to these old reliable reciprocating engines by Maritime Commission design engineers is Monel for main throttle and pilot valve seating surfaces, and Nickel-chromium alloyed cast iron for main throttle valve piston and piston keep.

In this class of service, 230 pounds W.S.P. steam superheated to 450° F., Monel assures maximum service life with minimum attention. Its strength and hardness at high temperature resist wire drawing across seating surfaces. Monel's heat expansion characteristics at these temperatures are close to those of steel and iron, thus assuring maintenance of initial fitting tolerances. In addition, Monel's immunity to corrosion safeguards highly finished valve surfaces against rusting by condensate during shut down periods.

Monel steam separators, Monel-trimmed soot blowers, Monel vent check valves, and Nickel Alloy refractory bolts are also standard on Liberty ships.

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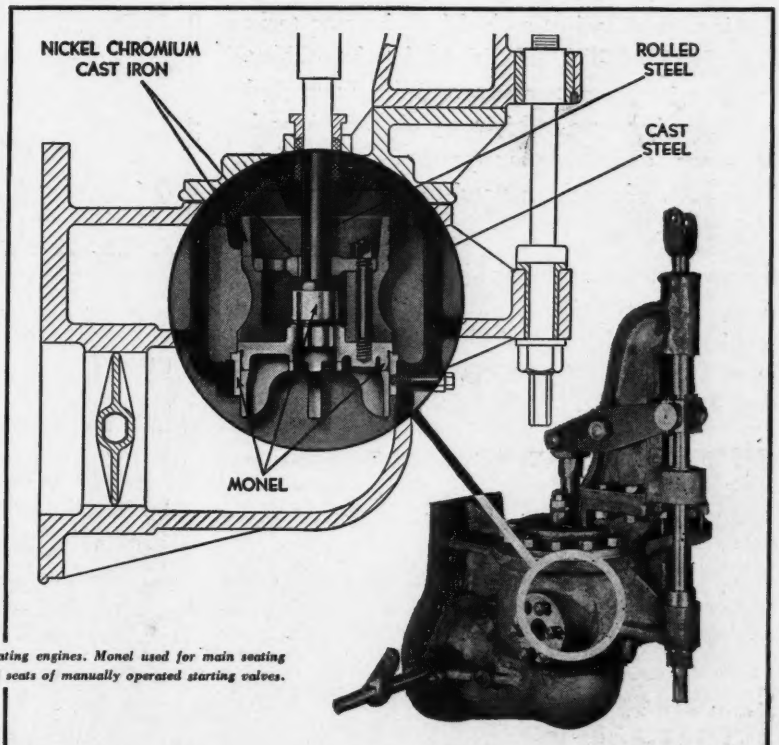

Main steam throttle valve for Liberty ship reciprocating engines. Monel used for main seating surfaces, pilot valve, disc and seat and for discs and seats of manually operated starting valves.

Photo courtesy of Prescott Company, Menominee, Mich.

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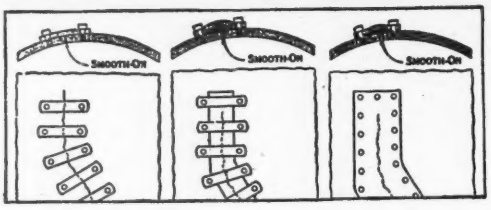
Thousands of plants use SMOOTH-ON as insurance against production delays



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21 **Heat Resisting Coatings**—A bulletin describing heat resisting coatings for metal that give continued protection to surfaces of metals from ordinary conditions to temperatures to 1800 deg. F. without discoloring, peeling or cracking. The coatings are said to be unaffected by fumes of sulphur dioxide, carbon dioxide, acetic acid or chlorine in the presence of moisture. Thurmalox Co.

22 **Portable Elevators**—A 40-ft. telescopic portable elevator for use on maintenance and construction work is described in Circular 30-203. Detailed are specifications, construction features and applications. Lewis Shepard Sales Corp.

23 **Coal Dryers**—The operation and mechanical features coal drying processes are fully explained in an illustrated bulletin on coal dryers. Moisture removal and the utilization of furnace gases through the operation of forced draft fans are detailed. McNally Pittsburg Mfg. Corp.

24 **Traveling Cranes**—The Why and How of Faster Production is the title of a 12-p. bulletin that shows the design and arrangement of traveling cranes for various industries. Included are application, construction features and illustrated engineering handling of materials. Reading Chain & Block Corp.

25 **Step-Valve Pump**—A bulletin explains how the step-valve is designed for specific purposes, also how it functions in pumping against pressures up to 20,000 lb. psi in handling materials such as butadiene, salt slurries, fibres in suspension, acid sludge, etc. Illustrations show typical valve designs and why the double-ball checks used in construction are claimed to be non-clogging and self-cleaning when pumping materials and liquids containing a considerable percentage of solids. Bulletin 426, Milton Roy Pumps.

26 **Manufacturing and Engineering Facilities**—A 20-p. booklet which editorially and pictorially shows the products, manufacturing and engineering facilities at work in the greater war effort. Many application pictures show possible use for products in war and peace time activities. Hobart Bros. Co.

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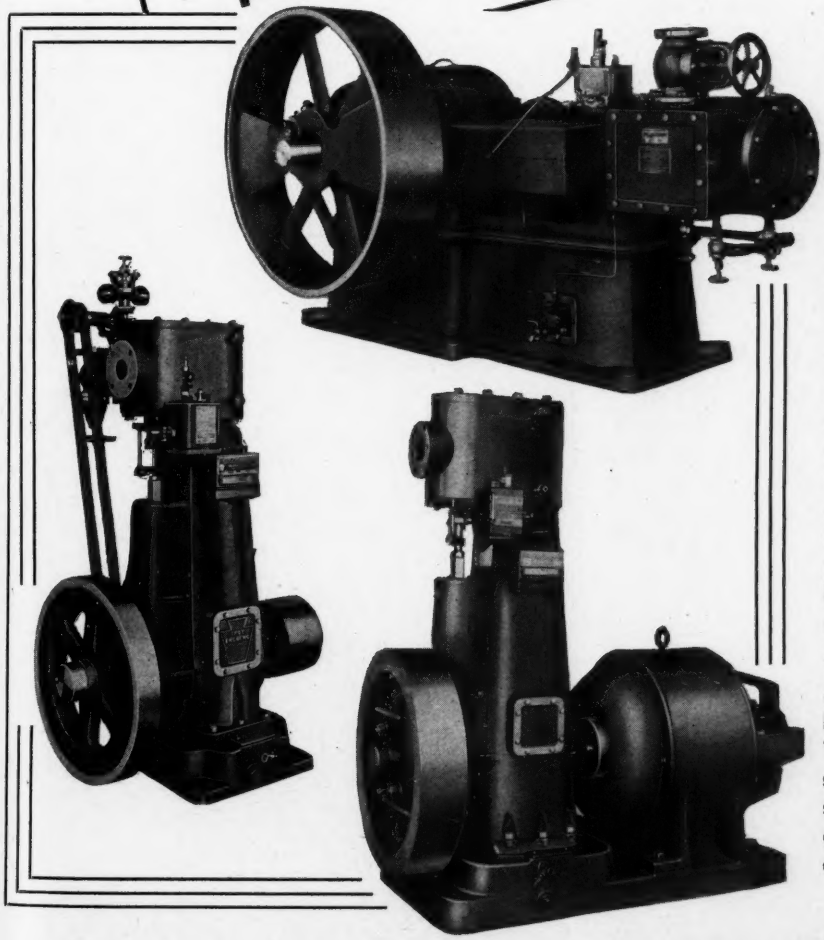
STEAM ENGINES *and* GENERATING SETS

...engines as drives for auxiliary equipment
...sets as the only source of power in small plants, or auxiliary power in large plants



They have a pretty good power cost record—these engines and sets. The average cost in many surveyed plants is only ½ cent per kw.h. It's a record that hardly can be ignored.

The Troy-Engberg Steam Engine is being used for driving all kinds of auxiliary equipment, such as: stokers, fans, blowers, pumps, compressors, cookers, dryers, etc. In small plants, it also is used for driving equipment but often is shipped with an AC or DC generator in the form of a Generating Set to provide the only current for light and power. Troy-Engberg Sets are also used in large plants for stand-by power; for week-end, night and holiday load, or for reducing demand charges.

Yes, Troy-Engberg Steam Engines and Generating Sets are definitely in the industrial plant picture. They are economical and have desirable drive characteristics. They should be considered by every engineer planning to modernize his drives and cut his power costs.

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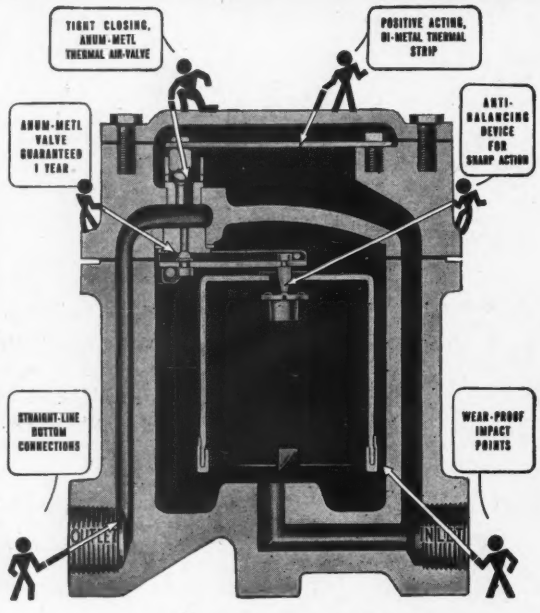
HERE'S THE SURE WAY TO GET HEAT FAST AND CHEAP



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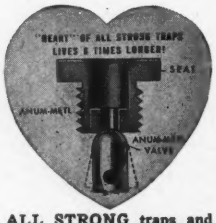

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Power Plant Construction News

Ala., Prichard—J. C. Sanders Cotton Mill Co., Mobile, Ala., plans installation of electric power equipment in proposed new mill at Prichard, comprising several large one and multi-story units. It is proposed to build a boiler house. Entire project is reported to cost over $700,000. Erection is scheduled to begin soon. H. Pembleton, 2121 Highland Ave., Birmingham, Ala., is architect.

Ark., Stamps—Arkansas Power & Light Co., Pine Bluff, will soon begin superstructure for proposed new steam-electric generating station in vicinity of Stamps, to be equipped for an initial capacity of 30,000 kw. Natural gas will be used as fuel. Completion is scheduled in 1943. Cost estimated close to $3,000,000, including transmission lines.

Calif., Merced—City and County of San Francisco, City Hall, San Francisco, Calif., have authorized construction of new pumping station at Lake Merced, for auxiliary service in connection with water supply system. It is estimated to cost about $1,250,000, with pumping units and accessories, power station and other facilities. Bond issue in amount noted has been authorized for project.

Colo., Lamar—War Department, Twentieth Street and Constitution Avenue, N. W., Washington, D. C., has plans under way for new air force training school in Lamar (exact location withheld). A boiler house and power substation are planned, with complete electric light and power distribution system and service facilities. Entire project is reported to cost over $5,000,000, and will be carried out under direction of United States Engineer Office, Albuquerque, N. M.

Idaho, Boise—G. R. McGill, 1818 Resseguie St., Boise, and associates have plans under way for new hydroelectric power plant on Quartz Creek, vicinity of Yellowstone, for light and power service for local community, and power supply for mining operations in that area. Permission has been granted for use of required water from stream and application has been made to State Public Utilities Commission for authority to proceed with project. No estimate of cost has been announced.

Ky., Lexington—Irving Air Chute Co., 1670 Jefferson Ave., Buffalo, N. Y., manufacturer of parachutes, plans installation of electric power equipment in new 1-story branch plant, 125 by 325 ft., at Lexington. Cost close to $125,000. Work will be placed under way soon. Mueller & Hair, Hamilton Hotel, Hamilton, Ohio, are architects.

Mich., Marysville—Detroit Edison Co., 2000 Second Ave., Detroit, has work in progress on expansion in steam-electric generating station at Marysville, with installation of new 75,000-kw. turbine-generator and auxiliary equipment. Completion is scheduled early next year, and will be followed by immediate further extensions in same station, to include another 75,000-kw. turbine-generator unit and accessories, expansion in switchyard, transmission and distributing lines, and other facilities. The project is expected to be completed by the end of 1943.

Minn., Rushford—Dairyland Power Cooperative, Inc., Arcadia, Wis., is considering extensions in power plant in vicinity of Rushford, with installation of additional equipment for increased capacity.

Mo., Kansas City—Pratt & Whitney Division, United Aircraft Corp., East Hartford, Conn., manufacturer of airplane engines and parts, plans installation of electric power equipment in new plant in Kansas City area (exact location withheld). It will comprise several large units. A boiler plant and power substation will be built. Entire project will cost over $5,000,000, with financing to be provided by Defense Plant Corp., Washington, D. C., a Federal agency. Work will begin soon. Albert Kahn Associated Architects & Engineers, Inc., New Center Building, Detroit, Mich., is architect and engineer.

Mo., Springfield—Springfield Gas & Electric Co., plans expansion in steam-electric generating station, including multi-story addition for extensions in steam department. Installation will include new boiler unit, pumping machinery, water heaters, fans and other auxiliary equipment. Cost reported close to $225,000. Proposed to award contracts at once and proceed with work.

Ohio, Cleveland—Sommer & Adams Co., 18511 Euclid Ave., manufacturer of special machinery and tools, plans

installation of electric power equipment in new 1-story addition, about 90 by 240 ft. Cost estimated over $100,000. Proposed to begin work soon. Edward G. Hoefler, 5005 Euclid Ave., is engineer.

Ohio, Dayton—War Department, Twentieth St. and Constitution Ave., N.W., Washington, D. C., has plans maturing for addition to power plant at military development in Ohio (exact location withheld). Bids will be asked by United States Engineer Office, Dayton.

Ohio, Hamilton—City Council has completed plans and has made application for priority rating for extensions and improvements in municipal power plant, including installation of new boiler unit and accessory steam-generating equipment. Extensions will be made in electrical distribution system in different parts of city. Complete program will cost about $230,000. Froehlich & Emery Engineering Co., Toledo Trust Building, Toledo, Ohio, is consulting engineer.

Ohio, Newark—Aluminum Co. of America, Inc., Gulf Building, Pittsburgh, Pa., plans installation of electric power equipment in new multi-unit aluminum bar and rod mill in vicinity of Newark (exact location withheld). A main power substation is planned with several auxiliary transformer stations. Entire project is reported to cost approximately $22,000,000, and is scheduled for completion in 1943.

Pa., Washington—Jessop Steel Co., manufacturer of alloy and high-speed steels, plans installation of electric power equipment in new 1-story addition to plant, about 135 by 160 ft. Cost reported over $100,000, including machinery.

Pa., Williamsport—Pennsylvania Power & Light Co., Allentown, Pa., plans extensions in steam division at steam-electric generating station at Williamsport, including installation of new boiler unit and auxiliary equipment. Proposed to carry out work soon.

R. I., Woonsocket—Woonsocket Rayon Co., Clinton St., has filed plans for new boiler house at mill, to be about 45 by 50 ft., and 50 ft. high. Cost reported over $50,000, with boiler units and auxiliary equipment. Work will be placed under way at once.

Tenn., Clarkesville—War Department, Twentieth St. and Constitution Ave., N. W., Washington, D. C., has authorized a new air force training school in vicinity of Clarkesville. A boiler house and power substation are planned, with complete electric light and power distribution system. Entire project is estimated to cost over $3,000,000. Work will begin soon. Allen & Hashal, and Walk C. Jones, Sr. and Jr., all of Memphis, Tenn., are architects and engineers. Project will be carried out under direction of United States Engineer Office, Nashville, Tenn.

Tenn., Kingsport—Tennessee-Eastman Corp., Kingsport, manufacturer of rayon products, chemicals, etc., plans installation of electric power equipment in new multi-unit plant in Tennessee (exact location withheld) for production for Government. A power substation and boiler house will be built. Entire project will cost over $3,000,000. Work is scheduled to begin soon and will be carried out under direction of United States Engineer Office, Kingsport.

Texas, Lubbock—War Department, Twentieth St. and Constitution Ave., N. W., Washington, D. C., plans boiler house and power substation at proposed new air force training school in vicinity of Lubbock. A complete electric light and power distribution system will be installed, including air field power facilities. Entire project is estimated to cost over $3,000,000. McMillan, Glover & McCullough, Lubbock, are architects and engineers. Construction will be supervised by United States Engineer Office, Albuquerque, N. M.

Wash., Seattle—Bureau of Mines, Department of Interior, C and Eighteenth Sts., N. W., Washington, D. C., plans large electro-development laboratory in Pacific Northwest, exact location to be determined soon, for investigations for recovery and processing of various minerals found in that area. Laboratory will consist of several units and will be completely electrified, securing power supply from Bonneville and Grand Coulee hydroelectric generating stations of Government. Cost about $500,000. Work will be carried out at early date.

Wis., Spooner—Town Council has made application for Federal permission to construct proposed municipal hydroelectric power plant, to be operated in conjunction with an existing municipal station of same type. Cost estimated about $250,000, with hydraulic turbines and auxiliary equipment. L. A. DeGuere, Wisconsin Rapids, Wis., is consulting engineer.

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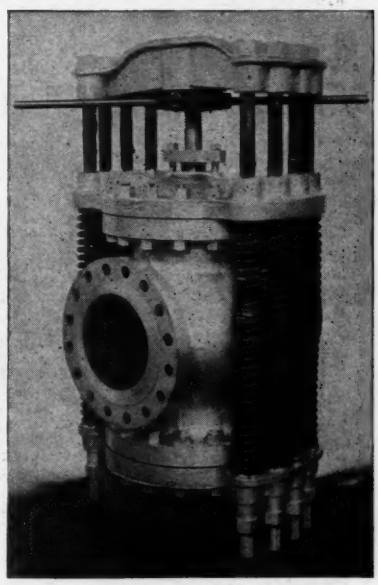

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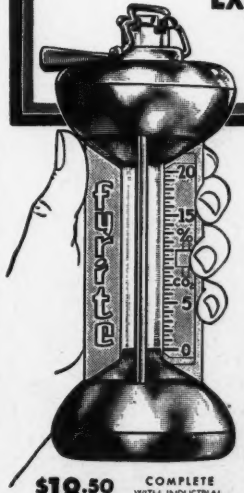

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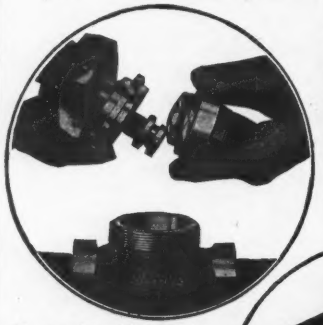

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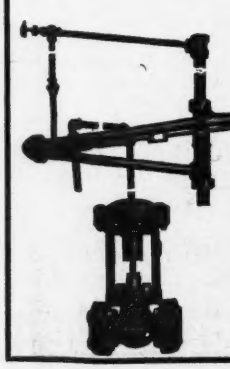

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Where to Buy DIRECTORY

GREASE, LUBRICATING
Cities Service Oil Co.
Shell Oil Co., Inc.
Socony-Vacuum Oil Co., Inc.
Standard Oil Co. (Indiana)
Sun Oil Company
Texas Company, The
Tide Water Associated Oil Co.

HEATERS, WATER
American District Steam Co.
Lummus Co., The

HEAT EXCHANGERS
Kellogg Co., The M. W.
Lummus Co., The
Marley Company, The
Vogt Machine Co., Inc., Henry

HOISTS
American Eng'r'g Co.

HOSE
United States Rubber Co.

ICE MAKING AND REFRIGERATING MACHINERY
Vogt Machine Co., Inc., Henry
Worthington Pump & Machy. Corp.

ILLUMINATORS, GAUGE GLASS
Ernst Water Column & Gage Co.

INSTRUMENTS, ELECTRICAL
Biddle Co., Jas. G.
General Electric Company
Leeds & Northrup Co.

INSULATION, HEAT
American Dist. Steam Co.
Ehret Magnesia Mfg. Co.
Johns-Manville

INSULATION TESTERS
Biddle Co., Jas. G.

INSULATING MATERIAL
General Electric Company

JOINTS, EXPANSION
American District Steam Co.
Yarnall-Waring Company

LUBRICANTS
Cities Service Oil Co.
Shell Oil Co., Inc.
Socony-Vacuum Oil Co., Inc.
Standard Oil Co. (Indiana)
Sun Oil Company
Texas Company, The
Tide Water Associated Oil Co.

LUBRICATING PASTE
Crane Packing Co.
Garlock Packing Co., The

LUBRICATORS
Bowser & Co., Inc., S. F.
Lunkenheimer Co., The
Manzel Brothers Company
Powell Co., The Wm.
Williams Valve Co., The D. T.

MAGNETIC SEPARATORS
Cutler-Hammer, Inc.

MECHANICAL DRAFT APPARATUS
American Blower Corp.
Green Fuel Economizer Co.

METAL ENCLOSED CUBICLE CONTROL
Cutler-Hammer, Inc.

METERS, AIR AND GAS
American Dist. Steam Co.
Bailey Meter Company
Cochrane Corp.
Republic Flow Meters Co.

METERS, BOILER
Bailey Meter Company
Hays Corporation, The
Republic Flow Meters Co.

METERS, COAL
Bailey Meter Company
Beaumont Birch Co.

METERS, WATER AND STEAM
American District Steam Co.
Bailey Meter Company
Infilco Incorporated
Cochrane Corporation
Hensley Company
Republic Flow Meters Co.
Simplex Valve & Meter Co.

MONEL METAL RINGS, RODS, CASTINGS, FORGINGS, TUBING, SHEETS, WIRE AND WIRE CLOTH
International Nickel Co., Inc.

MOTOR CONTROL
Cutler-Hammer, Inc.

MOTORS
Allis-Chalmers Mfg. Co.
Elliott Company
General Electric Company
Westinghouse Elec. & Mfg. Co.

MUFFLERS
Burgess Battery Co.

NOZZLES FOR ALL PURPOSES
Bacharach Ind. Inst. Co.
Marley Company, The
Yarnall-Waring Company

NOZZLES, BOILER
Taylor Forge & Pipe Wks.

OIL AND GREASE CUPS
Lunkenheimer Co., The
Powell Co., The Wm.
Williams Valve Co., The D. T.

OIL BURNING EQUIPMENT
Engineer Co., The

OILING AND FILTERING SYSTEMS
Bowser & Co., Inc., S. F.

OILING DEVICES
Bowser & Co., Inc., S. F.

OILS, CUTTING
Cities Service Oil Co.
Shell Oil Co., Inc.
Socony-Vacuum Oil Co., Inc.
Standard Oil Co. (Indiana)
Sun Oil Company
Texas Company, The
Tide Water Associated Oil Co.

OILS, FUEL
Cities Service Oil Co.
Shell Oil Co., Inc.
Socony-Vacuum Oil Co., Inc.
Standard Oil Co. (Indiana)
Sun Oil Company
Texas Company, The
Tide Water Associated Oil Co.

OILS, LUBRICATING
Cities Service Oil Co.
Shell Oil Co., Inc.
Socony-Vacuum Oil Co., Inc.
Standard Oil Company (Indiana)
Sun Oil Company
Texas Company, The
Tide Water Associated Oil Co.

OIL PUMPING AND HEATING EQUIPMENT
Engineer Co., The

OIL STORAGE EQUIPMENT
Bowser & Co., Inc., S. F.

OIL TANKS
Bowser & Co., Inc., S. F.
Graver Tank & Mfg. Co., Inc.
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COMPLETE SYSTEMS ★ ★ ★

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Crane Packing Co.
Ehret Magnesia Mfg. Co.
France Packing Co.
Garlock Packing Co., The
Johns-Manville
Raybestos-Manhattan, Inc.

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Belmont Pkg. & Rubber Co., The
Crane Packing Co.
France Packing Co.
Garlock Packing Co., The
Raybestos-Manhattan, Inc.

PACKING, PISTON AND ROD, VALVE STEM
Belmont Pkg. & Rubber Co., The
Combination Pump Valve Co.
Crane Packing Co.
Ehret Magnesia Mfg. Co.
France Packing Co.
Garlock Packing Co., The
Johns-Manville
Raybestos-Manhattan, Inc.
United States Rubber Co.

PACKING, SHEET, VALVE, PUMP
Belmont Pkg. & Rubber Co., The
Crane Packing Co.
Ehret Magnesia Mfg. Co.
France Packing Co.
Garlock Packing Co., The
Johns-Manville
Raybestos-Manhattan, Inc.
United States Rubber Co.

PAINT, ANTI-CORROSIVE, METAL, PROTECTIVE, STEEL PRESERVATIVE, HEAT RESISTING
Dampney Co. of Amer.

PHOSPHATE CONTROL EQUIPMENT
Betz, W. H. & L. D.
Taylor & Co., W. A.

Ph CONTROL EQUIPMENT
Betz, W. H. & L. D.
Taylor & Co., W. A.

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American Pipe Bending Mach. Co.
Watson-Stillman Co., The

PIPE COILS AND BENDS
American Dist. Steam Co.
Grinnell Company, Inc.
Kellogg Co., The M. W.
Midwest Piping & Supply Co.
National Valve & Mfg. Co.
Rempe Company
Scovill Mfg. Co.
Taylor Forge & Pipe Wks.
Vogt Machine Co., Inc., Henry

PIPE COVERING
American District Steam Co.
Ehret Magnesia Mfg. Co.
Johns-Manville
Porter Co., H. W.

PIPE SAVERS
Sarco Company, Inc.

PIPE SUPPORTS, GUIDES
American District Steam Co.
Grinnell Company, Inc.

PIPE, SPIRAL WELDED
Taylor Forge & Pipe Wks.

PIPING MANUFACTURERS, FABRICATORS
Grinnell Company, Inc.
Kellogg Co., The M. W.
Midwest Piping & Supply Co.
National Valve & Mfg. Co.
Steel & Tubes Division of Republic Steel Corp.
Taylor Forge & Pipe Wks.

POWER METAL
Magnolia Metal Co.

POWER TRANSMISSION EQUIPMENT
Gilmer Co., L. H.
Link-Belt Co.
Morse Chain Co.
United States Rubber Co.
Worthington Pump & Machy. Corp.

PROPORTIONING MACHINES
Haering & Co., Inc., D. W.
Taylor & Co., W. A.
Wilson Chemical Feeders, Inc.

PROTECTIVE COATING
Dampney Co. of Amer.

PULVERIZED FUEL EQUIPMENT
Beaumont Birch Co.
Combustion Engrg. Co., Inc.
Foster Wheeler Corporation

PULVERIZERS
American Pulverizer Co.
Pennsylvania Crusher Co.

PUMP PRIMING SYSTEMS
De Laval Steam Turbine Co.

PUMPS, BARREL
Blackmer Pump Co.

PUMPS, BOILER FEED
Aldrich Pump Co.
Allis-Chalmers Mfg. Co.
De Laval Steam Turbine Co.
Warren Steam Pump Co., Inc.
Worthington Pump & Machy. Corp.

PUMPS, CENTRIFUGAL
Aldrich Pump Co.
Allis-Chalmers Mfg. Co.
De Laval Steam Turbine Co.
Pomona Pump Co.
Quimby Pump Co., Inc.
Warren Steam Pump Co., Inc.
Worthington Pump & Machy. Corp.

PUMPS, DEEP WELL
Aldrich Pump Co.
Pomona Pump Co.

PUMPS, ELEVATOR, FIRE AND GENERAL SERVICE
De Laval Steam Turbine Co.
Quimby Pump Co., Inc.
Warren Steam Pump Co., Inc.

PUMPS, HYDRAULIC PRESSURE
Aldrich Pump Co.
Blackmer Pump Co.
Warren Steam Pump Co., Inc.

PUMPS, OIL
Bowser & Co., Inc., S. F.
Blackmer Pump Co.
De Laval Steam Turbine Co.
Engineer Co., The
Manzel Brothers Company

PUMPS, PORTABLE POWER
Blackmer Pump Co.

PUMPS, POWER, ELECTRIC
Aldrich Pump Co.
Blackmer Pump Co.
Quimby Pump Co., Inc.
Warren Steam Pump Co., Inc.
Worthington Pump & Machy. Corp.

PUMPS, RECIPROCATING
Watson-Stillman Co., The

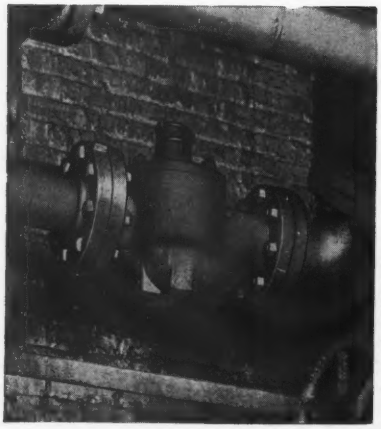
PUMPS, ROTARY
Blackmer Pump Co.

PUMPS, STEAM JACKETED
Blackmer Pump Co.

PUMPS, TURBINE
Warren Steam Pump Co., Inc.

PUMPS, VACUUM
Fuller Company
Warren Steam Pump Co., Inc.

PUMPS, WATERWORKS
Pomona Pump Co.
Warren Steam Pump Co., Inc.



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BOILER FEED WATER
METERS
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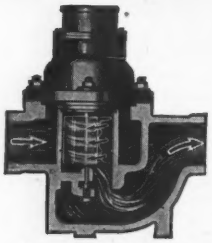
Why? Because the Henszey Meter was developed to measure hot, dirty corrosive boiler blowdown. There are no close clearances to cause trouble. There are a minimum of moving parts. The Henszey Meter is equally accurate at high or low flow, high or low pressure on reciprocating, duplex, triplex or centrifugal pumps. It can be calibrated to read in gallons, pounds or cubic feet at any specified temperature. Sizes 10 to 600 G.P.M., cold water steady flow rating. Connections: ¾" to 6". Special sizes to order.



Here's how it works
Water enters the measuring chamber tangentially, spinning in the chamber as it passes through, forming a vortex. Each gallon that passes through this chamber makes the same number of revolutions of the water. A vane is placed in the rotating water to impart this rotation to the register.

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Elgin Softener Corp.
Graver Tank & Mfg. Co., Inc.
Infilco Incorporated
Permutit Co., The

PURIFIERS, OIL
Bowser & Co., Inc., S. F.

PURIFIERS, STEAM
Cochrane Corp.
Hagan Corporation
Infilco Incorporated
Marley Company, The

PYROMETERS
Bailey Meter Co.
Brown Instrument Co., The
Leeds & Northrup Co.

RECORDING INSTRUMENTS
American Dist. Steam Co.
Bacharach Ind. Inst. Co.
Cochrane Corp.
Leeds & Northrup Co.
Sarco Company, The
Simplex Valve & Meter Co.

REFRACTORIES
Atlas Lumnite Cement Co., The
Carborundum Co., The
Wahl Refractories Products Co.

REFRACTORY PATCHING MATERIAL
Atlas Lumnite Cement Co., The
Kellogg Co., The M. W.
Wahl Refractories Products Co.

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American Coal Burner Co.
Askania Regulator Co.
Atlas Valve Company
Cash Company, A. W.
Hagan Corporation
Hays Corporation, The
Republic Flow Meters Co.

REGULATORS, FAN ENGINE
Askania Regulator Co.
Atlas Valve Company
Foster Engrg. Co.

REGULATORS, FEED WATER
Atlas Valve Company
Bailey Meter Company
Northern Equipment Company
Republic Flow Meters Co.
Squires Company, The C. E.
Swartwout Co., The

REGULATORS, PRESSURE
Askania Regulator Co.
Atlas Valve Company
Cash Company, A. W.
Davis Regulator Co.
Fisher Governor Co.
Foster Engrg. Co.
Hagan Corporation
Northern Equipment Company
Republic Flow Meters Co.
Sarco Company, Inc.
Squires Company, The C. E.
Strong, Carlisle & Hammond Co.
Swartwout Co., The

REGULATORS, TEMPERATURE
Askania Regulator Co.
Atlas Valve Company
Foster Engrg. Co.
Sarco Company, Inc.

REPAIR AND RESURFACING MATERIAL
Flexrock Company
Smooth-On Mfg. Co.

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Leavitt Machine Co., The

RESISTANCES
Cutler-Hammer, Inc.

RHEOSTATS
Cutler-Hammer, Inc.

RINGS, CHILL
Wedge Protectors, Inc.

RUST PREVENTIVES
Dearborn Chemical Company
Haering & Co., Inc., D. W.

SCALE REMOVERS, MECHANICAL
Airetool Mfg. Co.
Brunt Equipment Co.
Elliott Company
Roto Company, The

SCALE REMOVING COMPOUNDS
Bird-Archer Co., The
Buromin Co., The
Dearborn Chemical Company
Electric Chemical Co.
Haering & Co., Inc., D. W.

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Beaumont Birch Co.
Sauerman Bros., Inc.

SCALES, COAL
Beaumont Birch Co.
Richardson Scale Co.
Syntron Company

SCRAPERS, TUBE
Brunt Equipment Co.

SEAMLESS TUBES
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Elliott Company
Hagan Corporation
Marley Company, The
National Valve & Mfg. Co.
Nicholson & Co., W. H.
Strong, Carlisle & Hammond Co.
Swartwout Co., The
Williams Valve Co., The D. T.

SEPARATORS, COMP. AIR
Leavitt Machine Co., The

SHAFTING
Steel & Tubes Division of Republic Steel Corp.

SIGHT FLOW INDICATORS
Cochrane Corp.

SILENCERS
Burgess Battery Co.

SODIUM ALUMINATE
Dearborn Chemical Company
National Aluminate Corporation

SPEED INDICATORS
Biddle Co., Jas. G.

SPEED REDUCERS, CHAIN
Link-Belt Co.
Morse Chain Co.

SPRAY COOLING EQUIPMENT
Marley Company, The
Pritchard & Co., J. F.
Yarnall-Waring Company

SPRINKLERS
Grinnell Company, Inc.

SPROCKET RIMS
Babbitt Steam Specialty Co.

SPROCKETS
Morse Chain Co.

STEAM TRAPS
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Anderson Co., The V. D.
Armstrong Machine Works
Cochrane Corporation
Crane Co.
Davis Regulator Co.
Fisher Governor Co.
Golden-Anderson Valve Specialty Co.
Nicholson & Co., W. H.
Sarco Company, Inc.
Squires Co., The C. E.
Strong, Carlisle & Hammond Co.
Swartwout Co., The
Williams Valve Co., The D. T.
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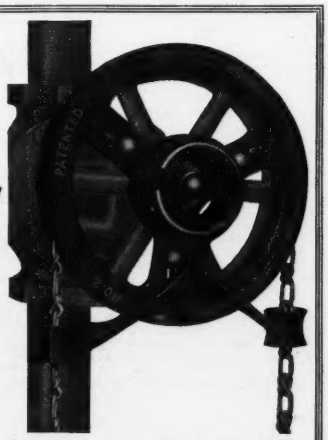

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Babcock & Wilcox Tube Co.
Combustion Engrg. Co., Inc.
Detroit Stoker Company
Flynn & Emrich Co.
Iron Fireman Mfg. Co.
Westinghouse Elec. & Mfg. Co.

STOKERS, UNDERFEED
American Engrg. Company
Combustion Engrg. Co., Inc.
Canton Stoker Corp.
Detroit Stoker Company
Flynn & Emrich Co.
Iron Fireman Mfg. Co.
Link-Belt Co.
Westinghouse Elec. & Mfg. Co.

STRAINERS
Cash Company, A. W.
Davis Regulator Co.
Edward Valve & Mfg. Co., Inc., The
Elliott Company
Fisher Governor Co.
Nicholson & Co., W. H.
Sarco Company, Inc.
Strong, Carlisle & Hammond Co.
Yarnall-Waring Co.

SUPERHEATERS, STEAM
Babcock & Wilcox Co., The
Combustion Engrg. Co., Inc.
Foster Wheeler Corporation
Marley Company, The

SWITCHBOARDS
General Electric Company

SWITCHES, SAFETY
Cutler-Hammer, Inc.

TACHOMETERS
Biddle Co., James G.
Brown Instrument Co., The

TANKS
Graver Tank & Mfg. Co., Inc.
Kellogg Co., The M. W.

THERMOMETERS, DIAL
Sarco Company, Inc.

THERMOMETERS, INDICATING & RECORDING
Leeds & Northrup Co.

TILE CONDUIT FOR STEAM LINES
American District Steam Co.
Porter Co., H. W.
Ric-Wil Co., The

TRAPS, COMPRESSED AIR, VACUUM
American Blower Corp.
Anderson Co., The V. D.
Armstrong Machine Works
Nicholson & Co., W. H.
Sarco Company, Inc.
Strong, Carlisle & Hammond Co.

TRAPS, STEAM, RADIATOR AND RETURN
American District Steam Co.
Anderson Co., The V. D.
Armstrong Machine Works
Nicholson & Co., W. H.
Sarco Company, Inc.
Strong, Carlisle & Hammond Co., The
Yarnall-Waring Company

TUBE CLEANERS, BOILER AND CONDENSER
Airetool Mfg. Co.
Brunt Equipment Co.
Elliott Company
Roto Company, The

TUBING
Scovill Mfg. Co.
Steel & Tubes Division of Republic Steel Corp.

TURBINES, STEAM
Allis-Chalmers Mfg. Co.
De Laval Steam Turbine Co.
Elliott Company
General Electric Company
Murray Iron Works Co.
Terry Steam Turbine Co., The
Westinghouse Elec. & Mfg. Co.

TRY COCKS
Ernst Water Column & Gage Co.

UNDERGROUND HEATING SYSTEMS
American District Steam Co.
Ehret Magnesia Mfg. Co.
Johns-Manville
Porter Co., H. W.
Ric-Wil Company, The

UNIONS
Crane Co.
Dart Mfg. Co., E. M.
Edward Valve & Mfg. Co., Inc., The

UNIT HEATERS
American Blower Corp.
Cutler-Hammer, Inc.
Grinnell Co., Inc.
Murray Iron Wks. Co.

VALVE DISCS
Combination Pump Valve Co.
Fairbanks Company, The
Garlock Packing Company
United States Rubber Co.

VALVES, ACID
Everlasting Valve Co.

VALVES, AIR OPERATED
Everlasting Valve Co.

VALVES, ANGLE
Edward Valve & Mfg. Co., Inc., The
Everlasting Valve Co.

VALVES, ALTITUDE
Chapman Valve Mfg. Co., The
Fisher Governor Co.
Golden-Anderson Valve Specialty Co.
Simplex Valve & Meter Co.

VALVES, AUTOMATIC CUT-OFF
Edward Valve & Mfg. Co., Inc., The
Northern Equipment Company
R-S Products Corp.

VALVES, AUTOMATIC STOP AND CHECK
Chapman Valve Mfg. Co., The
Davis Regulator Co.
Edward Valve & Mfg. Co., Inc., The
Foster Engrg. Co.
Golden-Anderson Valve Specialty Co.
Powell Co., The Wm.

VALVES, BACK PRESSURE
Cochrane Corp.
Davis Regulator Co.
Fisher Governor Co.
Foster Engrg. Co.

VALVES, BLOWOFF
Chapman Valve Mfg. Co., The
Cochrane Corporation
Crane Co.
Edward Valve & Mfg. Co., Inc., The
Everlasting Valve Co.
Fairbanks Company, The
Powell Co., The Wm.
Reading-Pratt & Cady Division of American Chain & Cable Co.
Yarnall-Waring Company

VALVES, CHECK
Chapman Valve Mfg. Co., The
Combination Pump Valve Co.
Crane Co.
Edward Valve & Mfg. Co., Inc., The
Fairbanks Company, The
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Company
Lunkenheimer Co., The
Powell Co., The Wm.
Reading-Pratt & Cady Division of American Chain & Cable Co.
Vogt Machine Co., Inc., Henry
Williams Valve Co., The D. T.

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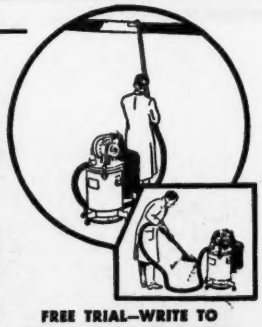

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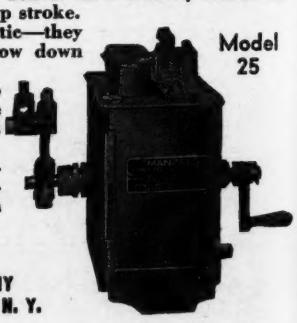

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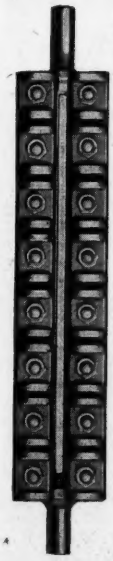

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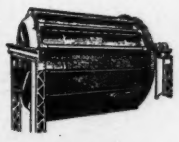
"PENNSYLVANIA" CRUSHERS



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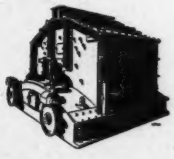

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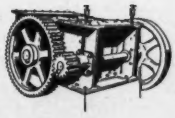

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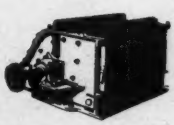

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In February, 1929, a large mill bought two Warren Pumps, each one to handle 1500 G.P.M. of a hot soluble compound, against a head of 58 feet.

Because of previous experience with other makes of pumps, a spare rotating member was ordered for each Warren Pump. Today, 13 years later, the spare parts are still in the boxes in which they were shipped, and have never been used.

If that is the kind of performance you want, get in touch with Warren.

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Fire Power

24 Hours a Day . . . 7 Days a Week with Iron Fireman *POWERAMS*

Nine Powerams in the Bear Creek Oil Pumping Station of National Transit Co. (A 10th unit has been added since above photograph was made.)

National Transit Company Operates 10 Powerams

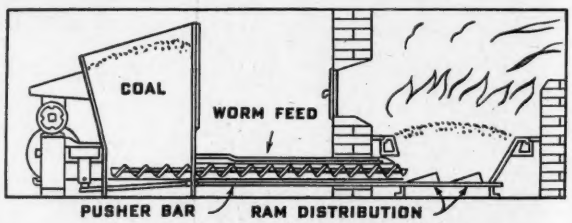
WARTIME operating conditions demand greater fire power—*more reliable* fire power—than ever before, and Iron Fireman heavy duty industrial stokers *are delivering it.*

Urgent war needs make it necessary to operate the Bear Creek Oil Pumping Station of the National Transit Company, Parker's Landing, Pa., at top efficiency, month in and month out, 24 hours a day, seven days a week.

Here Iron Fireman Poweram underfeed stokers are maintaining a steady steam pressure, under heavy load conditions which enables the pumps to operate continuously, at top capacity.

Not only has the National Transit Company been able to cut fuel costs, but substantial coal tonnage is being saved, thus aiding our national war program.

Iron Fireman stokers are shipped from the factory complete with fans and automatic controls. Installations are quickly made. For full information, without cost or obligation, wire or write Iron Fireman Manufacturing Company, 3318 West 106th Street, Cleveland, Ohio.



To meet the most varied industrial firing requirements, 41 standard catalog sizes and models of Iron Fireman stokers are available. These include both underfeed and pneumatic spreader types, and hopper and bunker-feed models. Iron Fireman engineering assures you of the correct stokers for your plant, taking into account fuel, load and operating conditions.

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IRON FIREMAN AUTOMATIC COAL STOKERS

Now Tougher than Ever

...exclusive Chapman process gives even more wear-resistance to List 960 Small Valves

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...with Specially Super-Hardened seats and wedges

THE CHAPMAN VALVE MANUFACTURING CO., INDIAN ORCHARD, MASS., U.S.A.

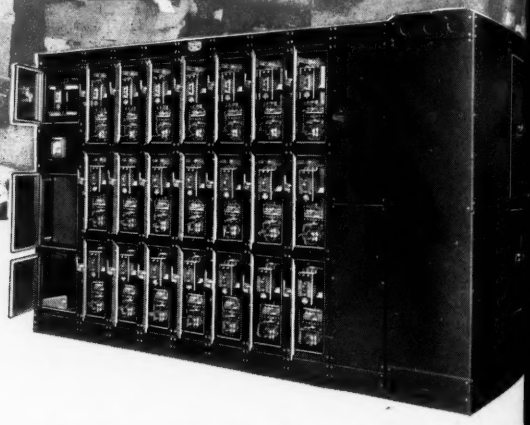
CHICAGO, AUGUST, 1942

UNITROL

REG. U. S. PAT. OFF.

Vital to Maximum Production

LET THIS TIME-SAVING, SPACE-SAVING, PRODUCTION-SAVING METHOD OF HOUSING AND CENTRALIZING MOTOR CONTROL SERVE YOU NOW



Every moment of delay, every extra and unnecessary machining, assembling and installation operation, every unnecessary interruption to vital production, every diversion of manpower from production to maintenance now assume tremendous importance. They must be eliminated. That is why men responsible for the fate of America's production effort are turning to Unitrol . . . the modern and better way of housing, installing and centralizing Motor Control.

Whether it's Motor Control for a single machine or Motor Control for an entire factory, Unitrol makes the task of its installation, servicing, change, extension or contraction so much easier that plant after plant is adopting Unitrol.

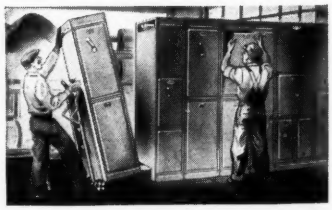
For those who don't know the many contributions of Unitrol to speed, space and production, there's the 32-page booklet "Unitrol . . . the next step forward in Motor Control progress" . . . free for the asking. Only, *ask for it now.* CUTLER-HAMMER, Inc., 1392 St. Paul Avenue, Milwaukee, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

1892—1942 50TH ANNIVERSARY

Unitrol is a *better* method of mounting, housing and centralizing Motor Control . . . from the individual unit up to the complete plant-serving motor control center. It is made up from standardized interchangeable parts. It is complete and usable at every step of the way. It is inexpensive, speedy and easy to install, demount or change. It is as "flexible as a rubber band."

The individual Unitrol *Section* houses Motor Control for several motors or motorized machines, is compact, space-saving, convenient and economical. No supports, no other structures or preparation necessary.

← The individual Unitrol mounting frame is *better* for machines with built-in Motor Control. It eliminates many machining, wiring and assembling operations.



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